

# **Reptile Face Masks**

## Preliminary Design Report

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### *Clients:*

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## **Abstract:**

The objective of this project is to construct four airtight masks for a Corn Snake and Bearded Dragon that can be attached to a pneumotachometer so the affects of opiates on reptile respiration can be measured. The masks should be non-invasive and comfortable for the test subjects while being easy to use and clean by the researchers. These masks will help our client collect respiratory data for a study analyzing the effects of opioids on reptile pain response and breathing.

## **Background:**

### **Problem Statement**

Dr. Kurt Sladky and Dr. Steve Johnson are investigating the effects of opioids on reptile respiration and pain response latency. Our clients have already collected relevant data for aquatic turtles, but they lack a device to collect pneumotachometric data from terrestrial reptiles. Two devices for a Corn Snake (Figure 1) and two devices for a Bearded Dragon (Figure 2) are required.

### **Problem Overview**

Two devices for each reptile species used are needed. The Corn Snake device must have an air-tight fit with the reptile's skin. Each device must have two ports, one for incoming air regulated at a constant pressure, and the other for outgoing air that leads to the pneumotachometer. The devices must be easy to use and easy to clean with common disinfecting detergents. Also, the devices must not harm the reptiles.



Figure 1: A Corn snake [6]



Figure 2: A Bearded Dragon [6]

### **Problem Motivation**

Very little research has been done on the effects of opioids on reptiles. There are no standard designs for reptilian pneumotachometric experiments currently on the market, making investigation of the effects of opioids on reptile respiration extremely difficult at this time. Research on anesthetics such as opioids is important because the proper dosage of anesthetics for reptiles during surgery is currently unknown. Over-anesthetizing the reptile may kill it while under-anesthetizing it might not suppress its pain. This research will allow us to determine the appropriate amount and type of opioids to use on the reptile to be effective without causing any harm.

## **Design Constraints**

There must be four separate airtight devices, two each for Corn Snakes and Bearded Dragons. The devices must be large enough to hold the reptile's head with a minimal amount of dead or unused space in the chamber. The snake has a neck ~ 10mm wide and ~ 9mm thick; the head is ~ 13mm wide, ~ 9mm thick and ~ 34mm long. The Bearded Dragon has a neck ~ 22mm wide and ~ 18mm thick; the head is ~ 40mm at the widest point, ~ 22mm thick, and ~ 47mm long. These devices must be comfortable for the laboratory reptiles. The devices should also be easy to use and clean by the researchers to keep the reptiles healthy.

There are several design features that must be considered in both pairs of pneumotachometer devices. All pneumotachometer device designs need to have two ports, one to allow air intake for inhalation and the second to allow exhaled air to pass to the pneumotachometer for data collection. The air intake port should be positioned so that the air flowing into the device does not blow directly into the reptile's face to avoid drying out the reptile's eyes. Our devices need to be rigid and airtight to ensure durability for experiments lasting two to eight hours and to prevent experimental errors in the pneumotachograph readings caused by air leakage. The devices need to be lightweight so that the reptiles are not strained or made uncomfortable. The devices must be made of non-toxic, allergen-free materials so that the reptiles are not harmed.

The device for the Bearded Dragon has a few additional design challenges. This device must fit snugly and create an airtight seal around the Bearded Dragon's spiky head using materials resistant to the Dragon's spikes. Also, the device needs to be secure and resistant to the Bearded Dragon's attempts to push the mask off with its forelegs. The Bearded Dragon has a mandible that is approximately 31.5 mm long, and the device must account for this length [6].

## **Pneumotachometry**

Pneumotachometry is a method used to measure the frequency, tidal volume, and peak air flow of breathing in animals and humans. A pressure difference exists between the two sides of a semipermeable resistive membrane (Figure 3). The high pressure on one side of the membrane forces the air to flow to the low pressure zone on the other side of the membrane. This air flow is directly proportional to the resistance of the membrane. The equation that governs this relationship is  $\Delta P = QR$ , where  $\Delta P$  is the pressure difference,  $Q$  is the air flow, and  $R$  is the resistance of the membrane to air flow [8]. Since we cannot directly measure air flow, we must measure the pressure difference. By hooking a simple differential pressure transducer up to the two sides of the membrane we can obtain this measurement. A sample reading from a pneumotachometer is shown in Figure 4.

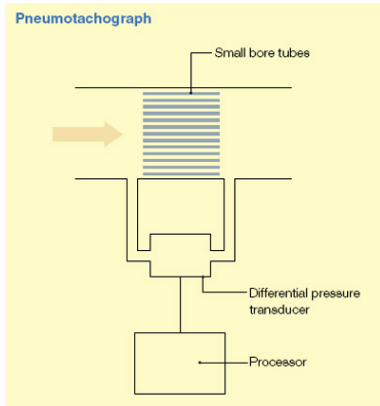


Figure 3:  
Pneumotachograph  
Schematic [8].

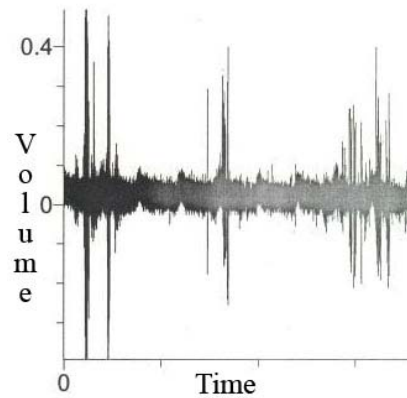


Figure 4: Data from a Pneumotachometer. The peaks represent the tidal volume and the distance between the peaks represents the time between the breaths [6].

### Physical Characteristics of Corn Snakes and Bearded Dragons

Corn Snakes have smooth even skin and narrow heads. The size of a Corn Snake's head does not increase proportionally with body size. Snakes can also dislocate their jaws. Bearded dragons have very spiky skin on the sides of the head and prominent brow ridges on the top of the head. Their skulls are much wider than their necks. Bearded Dragons can breathe through their mouths if their nose is blocked.

### Reptile Opioid Research

The effects of opioids on reptiles are widely unknown even though opioids are commonly used for pain treatment in both laboratory and research settings [7]. The reptile's response to opioid derivatives depends on which receptors ( $\mu$ ,  $\kappa$ , or  $\delta$ ) the species has and which receptors the specific opioid activates. Pain and breathing suppression are both effects of opioids on reptiles but they are not dependent on each other. For instance, the reptile may not have any pain suppression, yet have severely suppressed breathing. Our client hypothesizes that breathing suppression is linked to  $\mu$ - and  $\delta$ -opioid receptor activation. They plan to test this hypothesis by using butorphanol tartrate, morphine sulfate, oxymorphone, hydromorphone, DAMGO (a  $\mu$ -specific opioid agonist), DPDPE (a  $\delta$ -specific opioid agonist), and U69593 (a  $\kappa$ -specific opioid agonist) [7].

### Current Device

At this time our client does not have any kind of device to use on the Corn Snakes or Bearded Dragons. In their grant proposal the clients discussed using the end of a plastic 50 mL centrifuge tube for the device; however, they had no set method of attaching the device to the reptile or making an airtight seal.

## Competition

Many masks similar to our designs exist for anesthesia, but to our knowledge, masks for Bearded Dragons do not exist.



Figure 5: Anesthesia masks [7]

Anesthesia masks (Figure 5) consist of a simple bell shaped rigid frame generally made of clear plastic and a flexible rubber diaphragm over the open end. This diaphragm has a hole in it to fit the head of the animal. An airtight fit is not always guaranteed by this membrane.

Pneumotachometer masks for humans are commercially available, but are not designed for Bearded Dragons and are not small enough to fit a Corn Snake. There is also no guarantee that the input/output ports will fit the pneumotachometer in use by the client.

Previous experiments in pneumotachometry employed a variety of methods to make an airtight seal with the reptile's skin. In two academic papers [3, 4], either epoxy or dental putty was used to seal the nose and mouth to the input and output ports. The third paper's methods [1] used both a simple mask and a tracheal tube. This experiment showed that results from the mask and the tracheal tube were the same, so the invasive tracheal tube would not need to be employed in future pneumotachometry experiments. The simple mask was created by stretching a latex glove over an empty syringe tube and cutting a hole in the glove for the snake's head to fit in. The best example of a pneumotachometer mask (and one we wish to emulate) is found in a 1978 paper by Glass et al. [2]. This design is portable and stresses low dead space.

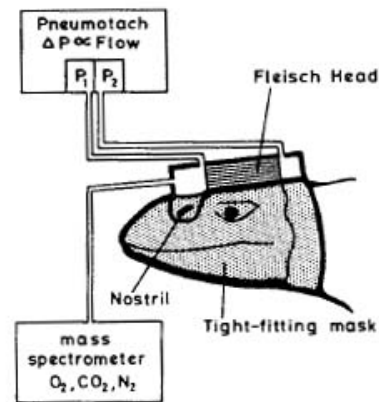


Figure 6: A previous design for a face mask on a lizard [2]

## Suggested Materials

### Body:

A simple piece of PVC pipe was a readily available material for the body of the mask. Alternatively, a clear plastic flexible hose was found. A rubber float for a toilet was also found for both a seal and a body.

### Airtight Seal:

Many materials were considered for a proper airtight seal. The first material tested was a latex glove, as seen in a design by our competition [1]. Rubber in various forms was also researched. Rubber washers with a radius of about 38 mm were obtained, as was a rubber float for a toilet. The rubber float was of a conical shape, ideal for

avoiding the spikes on the neck and head of the Bearded Dragon. Latex bands used in physical rehabilitation were considered because they are available in several strengths and thicknesses. The latex glove was too thin and tore easily, but the rehabilitation bands were less prone to ripping. However, this material was found suitable for the Corn Snake only. Some materials used in house thermal insulation were also considered such as putty used to seal windows as well as foam insulation used in doorways. Two variations of this foam were purchased, each with different pore sizes.

*Ports:*

A plastic hose adapter was found in the laboratory of Dr. Steve Johnson and was found to be sufficient.

*Joining of Materials:*

Two epoxies were found to join the mask materials. The first was a dual component plastic-to-plastic epoxy, and the second was chosen for its ability to join PVC to Plexiglas and acrylic. Zip-lock bag zippers were also considered for use in joining materials that were not to be permanently bonded.

**Alternate Designs**

*Design 1a:*

Forming the body of the mask, a PVC tube, 50.8 mm in diameter and 76.2 mm long, fits around the reptile's head. On one end of the pipe, a circular piece of Plexiglas is attached with a 10.72 mm hole drilled in the center for a pneumotachometer port. Another hole is drilled in the top of the PVC pipe to attach a second port. The back end of the pipe is attached to a funnel-shaped piece of rubber, approximately 1.59 mm thick. This rubber piece is cut down the side with each edge glued to the seal of a zip-lock bag. This creates a quick-release system to remove the reptile. The small end of the rubber cone will be lined with weather stripping approximately 6.35 mm thick. This end will create an airtight seal around the reptile's neck without choking it.

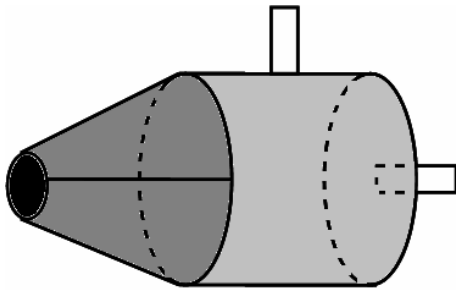


Figure 7: Full Head Design 1a

There are several pros and cons to this design. With the rubber funnel around the reptile's neck, the Bearded Dragon's spikes will not affect the airtight seal. Also, the zip-lock design allows the device to be removed quickly. This device will be attached behind the head, and is minimally invasive. However, it is heavy for the reptile and contains excess dead space. It is also time consuming to put on.

*Design 1b:*

The second Full Head design is a variation of the first. It has the same design idea except it uses a thin sheet of latex instead of a rubber funnel. The latex is stretched over the end of the PVC pipe and secured around the edge to create an airtight seal.

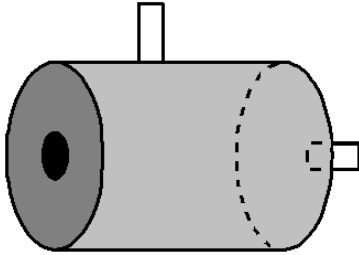


Figure 8: Full Head Design 1b

This design has similar pros and cons to the first Full Head design. This device fits behind the reptile's head and is minimally invasive. It is also relatively easy to use. However, it is heavy and has excess dead space. Also, the latex membrane could tear easily. Since the reptile's head needs to be pushed through a small hole, this design would only work on the Corn Snake.

*Design 2:*

The second design is the Nose Mask. This device is constructed using a plastic cap to cover the reptile's nose. It has straps attached to a collar around the reptile's neck to hold the mask in place. Ports are attached to the front end and under the bottom of the mask. Also, to create an airtight seal, there needs to be some sort of space-filling material around the edge of the mask.

There are pros and cons to the Nose Mask. This design is lightweight, has minimal dead space, and does not hurt the reptile's eyes. However, it can only be used on the Bearded Dragon due to the small size of the Corn Snake's head.

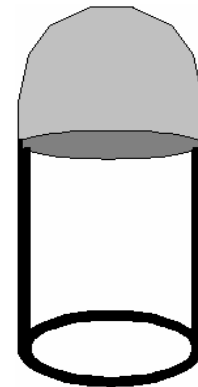


Figure 9: Nose Mask Design

*Design 3:*

The final design is the Nose Plugs. This involves construction of small tubes to be inserted into the nostrils of the reptile. Both tubes are connected to a common chamber that hooks into the input and output ports of the pneumotachometer and air pump, respectively. The Corn Snake does not breathe out of its mouth, but the Bearded Dragon has this ability. The mouth of the Bearded Dragon would have to be sealed to ensure that it would not breathe through its mouth.

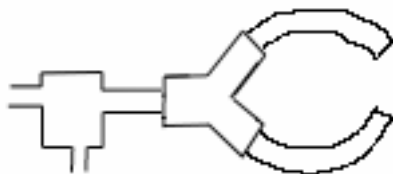


Figure 10: Nose Plug Design

The only pros of this design are that it is lightweight and there is no dead space. However, there are many cons. This design is invasive and requires the Bearded Dragon's mouth to be sealed

shut - a method we wish to avoid. Also, the nose plugs need to be secured to the nose to prevent them from being removed. This could restrict airflow and cause the animal immense discomfort.

### **Proposed Solution/Preliminary Design Matrix:**

To select a final design, a design matrix that addressed the most important criteria for our design was constructed. Using a point-based scale we rated each design on multiple criteria. The point-based scale allowed different requirements to have values based on their importance in the design specifications. As seen in the matrix, the Full Head mask design received the best score.

Design Requirements (points)	Full Head Mask	Nose Mask	Nose Plugs
Safety (15)	13	12	9
Non-invasiveness (30)	26	25	1
Versatility (20)	15	10	15
Ease of use (15)	12	10	5
Easy to Clean (15)	10	10	5
Cost (5)	3	3	3
<b>Total (100)</b>	<b>79</b>	<b>70</b>	<b>38</b>

### **Future Work**

We wish to complete testing of the prototypes of both the Corn Snake and Bearded Dragon masks to ensure that they are airtight and give acceptable pressure fluctuations to the pneumotachometer for data collection. The Corn Snake mask has already been tested and was found to be airtight. We also wish to test the reptile's comfort level in the masks. It is not known how the Corn Snake or Bearded Dragon will react to the mask or if they may try to pull it off. A restraint mechanism may be needed for the reptiles to ensure they do not dislodge the mask.

Improvements on the Full Head mask design will be completed during the remainder of the semester. The clients have requested an addition to the membrane of the Corn Snake mask to make it removable for easier cleaning. The team will also work to overcome obstacles related to creating an airtight seal for the Bearded Dragon.

The team has been instructed to create a small box for the reptile. The mask will be attached to the box so that the reptile is confined while the experiment is running. It is known that reptiles tend to act calmly when they feel enclosed, so a small box may be necessary.

A second set of masks will be produced after the final product is developed. A new body will be made out of a thinner material, so the mask will be lighter and the reptile may have freedom of motion. One consideration is the level of anxiety of the reptile during the experiment, and it is not known if the animal will experience more anxiety if they are in an opaque or transparent mask. This must also be taken into account during construction. A total of four masks are to be delivered, but it is not known if the client wishes to keep our current prototypes.

When the masks are delivered to the client and if time permits, the group may begin assisting the client with the experiment, or may write an academic paper on the construction of pneumotachometer masks.

**Appendix A:**  
**References**

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