

## Cheap Net-Traps to Reduce Risk of Venomous Snake Habu (*Protobothrops flavoviridis*) in Okinawa Island, Japan

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**Abstract:** Practical cheap tools are required to protect the inhabitants of the Okinawa and Amami Islands, Japan against encounters and bites of the venomous pit viper snake Habu (*Protobothrops flavoviridis*) in their houses and the surrounding environment. In this study, the researchers conducted laboratory and field experiments to identify the most effective net settings (i.e., mesh size and short supported nets versus long unsupported nets) for capturing Habu. We found that short net-traps of approximately 1 m in length with 25 mm mesh were the most effective with Habu being captured at a rate of >1 snake per 10 m net length per year in the field. This tool which is cheap and easy to maintain, entangles few non-target animals and applicable to reduce risk of other venomous snake species permanently in residential and farming areas.

**Key words:** Net-trap, cost-effective, maintenance-free, venomous snake, *Protobothrops flavoviridis*, Okinawa

### INTRODUCTION

Snake bites are medical emergencies in many parts of the world, especially in tropical and subtropical regions. Although, it has proved to be difficult to estimate the worldwide incidence of snake bite envenoming, it has been reported that there are 5 million snake bites, resulting in 2.5 million envenomings and 125,000 deaths each year (Chippaux, 1998). In subtropical Okinawa and Amami Islands, Japan, a viperid snake Habu (*Protobothrops* formally *Trimeresurus flavoviridis*) has been reported to bite over 100 inhabitants each year with an incidence of about 1 per 1500 people in several countryside districts. It is the largest native snake with adults having a maximum total length about 2 m. Inhabitants have been found to primarily encounter Habu when within about 20 m of woods and grassland (Ikehara *et al.*, 1982). In fact, approximately 85% of Habu bites have been recorded in residential and farming areas with several bites even reported in the rooms of city residences.

As a result, several studies have been focused on safeguarding houses and farming areas from Habu, to reduce the stress caused from fear of snake bites by inhabitants (Rodda, 1999). For example, local offices have attempted using baited traps to capture Habu however, this method was costly in terms of both finances and labor. It is impossible to exterminate Habu even in a small area in town and any projects to control Habu should be continued permanently. Some inhabitants would set fishing nets around their houses to reduce the risk of encountering Habu which resulted in some success in

capturing the snakes. However, this method was not authorized and is not widely used. Here, the researcher investigated the utility of nets to reduce the encounter rate with Habu. The researcher present a summary of the results of experiments using different types of nets (Aguni *et al.*, 2008; Katsuren *et al.*, 2008; Nishimura *et al.*, 2008; Terada, 2008) and provide a description of the method that has been found to be most practical to control Habu.

### MATERIALS AND METHODS

Laboratory experiments were conducted in the Okinawa Prefectural Institute of Health and Environment using an indoor enclosure of 1.5×1.5 m<sup>2</sup> and an outdoor enclosure of 10×10 m<sup>2</sup>. Field experiments were conducted at residential and farming areas that are situated in close proximity to woodlands and in woodlands of the middle and southern parts of Okinawa Island.

Both the laboratory and field experiments were carried out between 2002 and 2007 during which the effectiveness of different types of nets to capture Habu was examined including:

- New and discarded fishing nets
- New nets to protect farming products against birds

In the laboratory experiments, the mesh size of the nets that were used to capture Habu ranged between 13 and 30 mm. The laboratory experiments were conducted

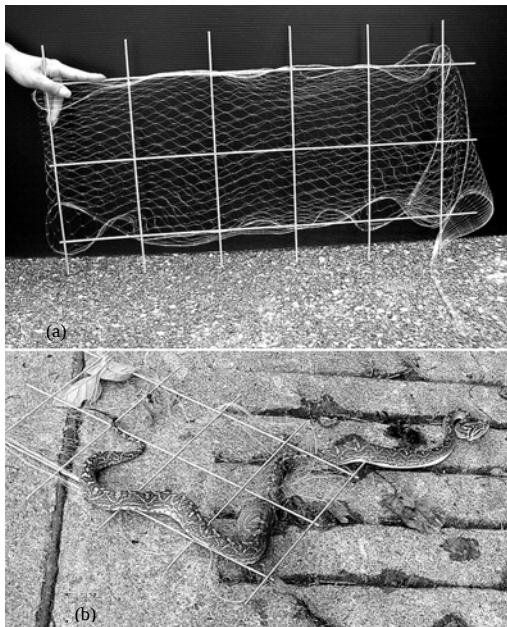


Fig. 1: (a) A fishing net of 25 mm mesh fixed onto an iron frame of 15 cm mesh and 75 cm length. (b) A 60 cm long net-trap with a captured Habu. The trap has been pierced vertically in the woods beside the road in Okinawa Island

by introducing Habu to the enclosures where the nets had been set up; two separate groups were assessed including snakes that:

- Had not been fed within a week (i.e., without stomach content,  $n = 82$ )
- Had been fed within 24 h prior to the onset of the experiment (i.e., with stomach content,  $n = 49$ )

The prey animals of the fed Habu included rats or musk shrews for large Habu and from one to several mice for small Habu.

In the field experiments, the mesh size of nets used to capture Habu ranged between 15-57 mm. Two classes of net size were utilized:

- Long nets of the 10 m class (5-20 m)
- Short nets of the 1 m class (0.6-1.5 m)

Following installation, net height ranged between 0.3 and 3 m with long nets being approximately 1 m in height and short nets being about 0.3 m in height. Long nets were set mainly on the surfaces of embankments or were strung between trees to hang vertically from the twigs of branches to the ground. Short nets were fixed onto an iron

frame that was 30-45 cm in height and 60-150 cm in length with 15×15 cm grids (Fig. 1). The cut ends of the frames were used to loosely wrap/tie the netting and were used as stakes to place them into the ground or in the gaps of embankments. The length of each net was used to measure its utility as a snake trap which was multiplied by the period of use to calculate the possibility of capturing snakes. Capture Rate (CR) was defined as the number of snakes that were captured per 10 m net length per year (/TMY).

## RESULTS

In the laboratory experiments with the unfed Habu (i.e., without stomach content), only 1 individual (measuring 1314 mm in snout-vent length) became entangled in a net of 18 mm mesh. The remaining Habu were not captured by the nets. In the experiments with Habu that had been fed (i.e., with prey in the stomach), a total of 26 Habu of size ranging from 1060-1410 mm were captured in nets with mesh size ranging from 20-28 mm. Of these 26 entangled individuals, 13 (50%) were dead by the morning after the experiments as a result of the net string constricting the trunk.

In the field experiments, several of the long nets set on the surfaces of retaining walls fell down. Even though this was not a problem with short nets, some did fall down after several months. Overall, 60 Habu were captured in the field. The mesh size of the nets that entangled Habu ranged from 18-30 mm. The minimum and maximum snout-vent length of captured Habu was 850 and 1540 mm, respectively and Habu of these 2 sizes were collected by the 25 mm mesh net. In 4 cases of capture we found only 1-4 vertebrae at the first examinations and discovered other bones including fangs after cleaning of fallen leaves at the bottom of the nets. In a sample of 11 out of the 60 captured Habu, 5 individuals were confirmed to have stomach content; 1 had matured eggs in the oviducts; 3 were found to have become entangled by rotating repeatedly within the net. For all Habu found before degradation had set in the string of the net had constricted the trunk in front of the stomach or the eggs.

In the field experiments, CR was low in nets with 18 and 30 mm mesh size. The CR of nets with 20-28 mm mesh was 0.28 in long nets that had been set in residential and farming areas (in 141.9 TMY) and 0.08 in nets set in woodlands (in 86.8 TMY). In both environmental settings, the nets with 25 mm mesh showed the highest CR, 0.40 (in 32.5 TMY) and 0.18 (in 33.2 TMY), respectively. CR was 1.07 in short nets that were set in residential and farming areas (in 11.2 TMY) while the CR of the 25 mm mesh

was 1.88 (in 5.5 TMY). Furthermore, other snakes were captured in the field. These included 10 *Dinodon semicarinatum*, 6 *Ovophis okinavensis* and 5 *Elaphe taeniura* individuals. One individual of each species was captured in the 25 mm mesh nets and the other individuals were captured in the  $\leq 20$  mm mesh nets. *O. okinavensis* is another venomous pit viper snake which causes  $>10$  bites per year to inhabitants in the islands. *E. taeniura* is an invasive species that has been introduced to Okinawa Island for which measures to control population size are required. In addition, the giant African land snail (*Achatina fulica*) which is also an invasive species in the islands and river crabs were captured at several spots. All of the snakes and most of the snails and crabs were captured in the long nets.

## DISCUSSION

A characteristic of Habu is that the maximum head width and height is similar to that of the trunk (Nishimura, 1984) and the body mass conditions increase with the growth of snout-vent length (Nishimura and Kamura, 1994). In the current study, most of the Habu that were captured in the field were large snakes with stomach content. The feeding frequency of adult Habu has been estimated to be approximately 10 or more prey items per year (Nishimura and Kamura, 1998). This frequency indicates a possibility of capturing a large individual by nets. To reduce the risk of Habu harming people, the number of large snakes should be reduced as:

- These individuals have large quantities of venom
- Large females are capable of laying many eggs which would increase the population size

The high capture rate of Habu during the field experiments indicates that the net-traps are an effective management strategy. The researchers have noticed few bones in 4 cases of capture and might have overlooked several Habu entangled by the traps. Entangled dead Habu decay to bones in 1-2 weeks and the estimated capture rates would be lower than the true values. The most appropriate net for controlling Habu was a short net of 25 mm mesh both in the capture rate and in the size range of captured Habu. Furthermore, the use of this type of net also reduces the risk of capturing non-target animals. Four to Six randomly placed short nets in the immediate vicinity of a house in Okinawa are suitable for controlling Habu. The total combined length of the nets is 3-6 m. More than 1 Habu is expected to be captured per year in locations where Habu density is high. On occasion, some Habu are still alive after capture (Fig. 1) hence, nets should not be set within the activity areas of children. The most suitable locations to set the nets are

between houses and adjacent woodlands or grasslands which are adjacent to the areas of high encounter rates and where children rarely go. If a path is present, the nets should be placed a few meters inside the woods for safety.

The price of a fishing net of 25 mm mesh which is 100 m in length and 2 m in width is about 40\$ while nets of 1 m squares cost about 20 cents. The material price of a short net with a plated iron grid is about 2\$. Wire of 3 m length may be used in place of the iron grid at a cost of about 60 cents. The required nets and wire for a single household would cost 3.60\$. The cost is zero if discarded nets and metal grids or wire are used.

After installation inhabitants had better inspect the traps a few times a year to clean of fallen leaves and debris. The trap remains effective even the net has been ripped or if the iron frame has been warped and is durable for  $>5$  years. Even discarded fishing nets have been ensured to have durability of  $>3$  years in the field experiments. The short net-trap does not fall down easily if 1 or 2 traps are set in an L shaped formation. These traps with firm installation are maintenance-free and keeping the snake density low. In general, most of the captured snakes eventually decay until only bones remain and are difficult to identify at inspection thus, inhabitants are unable to acknowledge the full effectiveness of the traps nor any results in the case without inspection.

Overall, this cheap and easily maintained method is applicable for the control of other snake species with a similar or larger trunk girth to the head following the pre-adaptation of several mesh sizes of nets to the target snake. Most suitable mesh size is a little larger than the head of large adult snakes. That is the total length of 4 sides of mesh is a little longer than the maximum girth of head. The location of trap installation could be adjusted to habitat use and behavior of the target snake like net-traps set around tree trunks to safeguard woodpecker nests from black rat snakes (Neal *et al.*, 1993). The traps should not be utilized in the central areas of large forests and grasslands where the human activity is low and the possibility of entangling non-problem native animals is high.

## CONCLUSION

In conclusion, a good proportion of people suffering from venomous snake bites around the world would occur in residential and farming areas and the net-trap is the most suitable method for permanent risk management in these areas particularly with respect to its cost effectiveness and ease of use.

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