SNAKE MITES *OPHIONYSSUS NATRICIS* (GERVAIS 1844) MORE COMMON THAN SNAKES IN THE TERRARIUM?

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Contents: Taxonomy - Occurrence - Life cycle - Sensory behaviour - Circumstances in wild snakes, and captive snakes respectively - Damage to snakes - Spread of the infestation - Diagnosis - Physical means of control - Chemical means of control - Recommended treatments - Prophylaxis - Snake mites on humans - References.

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Snake mites are a common scourge among our snakes. It seems they are more common in our terraria than the snakes themselves. Snake mites spread very easily and can cause a snake's death. This article is meant to give answers to what snake mites are, where they can be found, how they spread as well as how they can be discovered and fought.

TAXONOMY

Snake mites belong to the class Acarina (mites and ticks) which evolutionary are closely related to the spiders. The class Acarina belongs to the subphylum Chelicerata which belongs to the phylum Arthropoda (Frank 1981). The taxonomy in the class Acarina is being debated by the scientists. A classification of the snake mites is; order Parasitoformes, suborder Mesostigmata (prey mites), and family Laelaptidae with about 50 species (Frank 1981, Till 1967). The most common and important mite species for snakes is *Ophionyssus natricis* (Reichenbach - Klinke 1965, Frank 1981).

The species is being described under several different names, like *Dermanyssus natricis, Ichoronyssus serpentium, Liponyssus arabicus, Liponyssis natricis, Liponyssus serpentium, Ophionyssus arabicus, Ophionyssus easti, Ophionyssus natricis, Ophionyssus serpentium, Serpenticoloa easti, Serpenticola serpentium* and *Steatonyssus arabicus*. The first name under which it was described is *Ophionyssus natricis* (Gervais 1844) which belongs to the genus *Ophionyssus* (Mégnin) and thus it should be called (Camin 1949, Till 1967). The genus *Ophionyssus* has three species; *Ophionyssus natricis, Ophionyssus mabuyae* and *Ophionyssus lacertinus* (Till 1967, Frank 1981).

OCCURRENCE

Camin (1953) has suggested that the species *Ophionyssus natricis* does not have snakes as its natural host, because their way of life and qualifications offer the mites bad conditions to survive successfully on snakes in the wild. Camin suggests that the species - which is an almost perfectly adapted parasite for snakes in terraria - could have developed from mammal mites since people started to keep snakes in captivity.

Camin's theory, however, is being contradicted by Yunker (1956) who found mites on 47 of the 70 wild snakes of several species in the province of Gizeh in Egypt. Blanc & Alscione (1959) have also found mites on wild snakes in Marocco. According to Till (1967) *Ophionyssus natricis* occurs worldwide, mainly with snakes, but it has also been reported on lizards.

There are some minor differences between specimens from South Africa and specimens from America, but not sufficient to justify a division in two different species (Till 1967). It seems that the snake mites are spread most widely in snakes in zoos, where it is very common worldwide (Schroeder 1934, Till 1967, Frank 1981).

LIFE CYCLE

Camin has done a very comprehensive study on the life cycle and the sensory behaviour of the snake mite. The following report is taken from that work, if not stated otherwise. The life cycle of *Ophionyssus natricis* exists of five phases: egg, larva, protonymph, deutonymph and adult. Each immature phase changes only one time. The body of a mite consists in all phases of a saclike entity. The number of legs is six or eight.

Egg

The egg is a bit sticky when it has been laid and can stick to a surface, but it dries quickly and when it comes loose it then rolls around freely. It is egg-shaped and pearl white. Its average size is 0.34 x 0.23 mm. At a temperature of 20°C it hatches after four days (92-103 hours) and at 30°C it hatches after about one day (23-32 hours). When the eggs are exposed to 2°C for two weeks or to 40°C for 24 hours they die.

Dehydration is an important restrictive factor for the development of the eggs. A relative humidity of 95% is best, with a relative humidity of 50%, 78% of the eggs hatch and with a relative humidity of 35% it is impossible for the eggs to hatch because of dehydration, despite the fact that the embryonal development goes on normally.

Larva

Out of the egg comes a larva. It is soft and white and hexapodal, that means it has three pairs of legs (six legs). The larva has short hair (setae) on its body and three very long hairs on the end of its body. The average size is 0.38 x 0.24 mm. The larva has weak rudimentary mouth parts and eats nothing. It is slow and sluggish and can remain lying on the place where it hatched until it changes and becomes a protonymph.

At a temperature of 20°C the development till the slough takes about two days (45-48 hours) and with 30°C the development takes about one day (15-23 hours). At 2°C the mortality among the larvae is hardly 50% after three weeks and at 40°C the mortality is 100% within 12 hours. The larva is sensitive to dehydration in the same way as the egg.

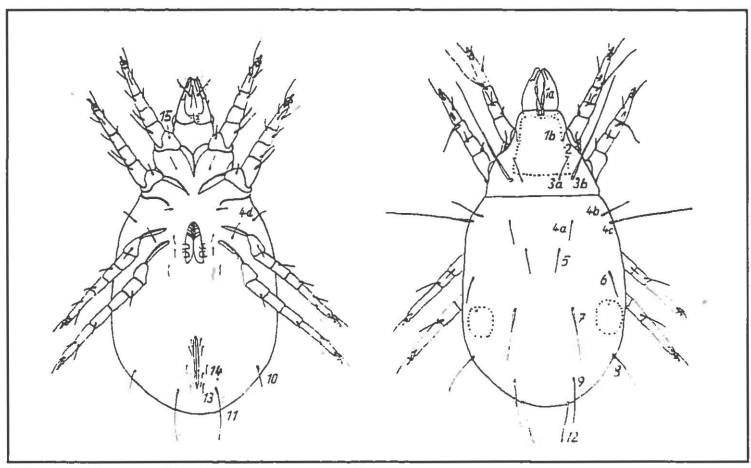
Protonymph

When the larva has changed it has become a protonymph. The protonymph is white or light brown as it hatches and about 0.36 x 0.23 mm big. It has short hairs on its body and is octapodal, that means it has four functional pairs of legs (eight legs).

The protonymph is the first active, eating phase with well developed mouth parts and claws. When it has eaten blood the colour becomes darker brown and the size increases to about 0.69 x 0.36 mm for a female and a little less for a male. After hatching the female walks around in the terrarium. When it comes into contact with a snake it

climbs on its body, crawls under a scale, sticks its mouth parts through the skin and sucks blood.

When the protonymph is not disturbed while it is eating it remains on the same place until it is full, but it does not cling tight like a tick. The protonymph can start eating within 12 hours after she has hatched and at a temperature of 25°C it takes 3-7 days until it is full, at 15°C it takes 16-21 days. After full engorgement the protonymph becomes active again, crawls out, drops from the snake, wanders away and congregates with other mites in dark corners. Those sitting in the corners of the eyes or under big ventral scales of the snake can remain there until they die as adults after laying eggs.



Schema of a *Acaride*. (Stammer, page. 7).

At 30°C it takes 12 hours from being eaten full until changing, at 25°C it takes 24 hours and at 20°C it takes 48 hours. Full engorgement seems necessary for the further development and the change to happen. In case the protonymph does not find a snake it climbs on objects in the terrarium where it congregates with other protonymphs and waits. When a moving object (for example a snake) comes into contact with the lumps of mites they swarm immediately out over it.

The protonymph can survive very long without food when there is no snake nearby. Under the circumstances that normally exist when one keeps snakes, the nymph can live without food for two to three weeks.

Deutonymph

After sloughing the protonymph has become a deutonymph. The deutonymph has very little hair on its body and is octapodal. It is dark red and about 0.7 x 0.4 mm big in case of a female, the male is a bit smaller. It has weak rudimentary mouth parts and does not eat.

The deutonymph is active but can only be found in the bottom substrate and running around in the terrarium, but never on the snake. The males can be separated from the females because of their smaller size and can often been seen on the backs of females.

The deutonymph phase lasts from 13 hours at 30°C until 26 hours at 20°C and 50 hours at 15°C. At 2°C and 40°C there is no development and the nymph dies. When the deutonymph sloughs she becomes adult.

Adult male

The adult male is from light yellow-brown to dark red or black, depending if he has eaten blood or only body fluids. It has quite a lot of hair on its body and it is octapodal. It is fast and sucks blood with well developed mouth parts. The adult male walks around the terrarium haphazardly and climbs on the back of the first unfed adult female, a deutonymph female or engorged female protonymph that it meets. The behaviour seems to be a reaction on the size of the female.

When the male meets a snake first, it climbs on it, eats and then leaves the snake and can mate afterwards. Males that feed on big snakes are never red or black, but light yellow-brown containing few snake blood cells. Seemingly the extra spermatofore-bearing outgrowth on the mouth parts hinders it at penetrating the snake just as deep as nymphs and females do, and they live on body fluids rather than blood.

When they live on small snakes they can get blood, however, and become dark red or black. The males are eaten full in 1-2 days, but they probably eat several times during their life time .It is not necessary for the male to eat before he mates and a male can mate with several females both before and after it has eaten. When mating it crawls from the female's back to her underside. There it lies down and holds her with its legs, with each pair of legs behind her corresponding legs in such a way that their genital openings lie against each other. Then the male bends its mouth parts backwards and takes a spermatofore from its genital opening which it puts in the vulva under the operculum of the female, during which they both sway their bodies. Mating is over in a couple of minutes and the male gets off to repeat the procedure with the next female that it might come across. The life span of the male is directly affected by temperature and humidity, and is about just as long or somewhat shorter than the female's.

Adult female

The adult female is about 0.57 x 0.35 mm before she has eaten but increases to about 1.35 x 0.96 mm after a meal of snake blood. The body is so richly covered with medium long, slightly bent hairs that it looks hairy.

The adult female is octapodal, very active, and a rapacious blood sucker that increases its weight from about 0.05 mg to 0.75 mg when it has eaten, an increase of 1500%. An adult female eats within a few hours after sloughing when she meets a snake, but otherwise she can manage for a long time without food, depending on temperature and humidity.

Between her slough and first meal the female copulates with whatever adult male she comes into contact with and sometimes she copulates with several males. When she has reached a weight of more than 0.15 mg she is no longer attractive for the males, and many females are never mated because they started eating before they met a male. Females that did not mate still lay small, unfertilized eggs that all develop into males. Females that did mate lay both small, unfertilized eggs that develop into males as well as big fertilized eggs that develop into females.

A female mite that meets a snake climbs on it and crawls away under a scale where it starts sucking blood. Most of the time it stays in the same place until it is fully engorged, when it is not being disturbed of course. Because the body increases so much in size, in the end only a part of it can be hidden under a scale.

When it has eaten enough the female walks around on the snake's body until it loses contact and falls off. It then walks around in the terrarium until it remains lying still (akinetic) in a dark corner. Another female that passes by lies down next to it and in that way the females congregate and lay their eggs. Sometimes a female can lay some eggs on the host while she is eating, but she cannot lay eggs before she has reached a weight

of at least 0.25 mg. At 25°C the female must eat for 4-6 days before she can lay eggs and she is eaten full after 5-8 days. Nearly all eggs are being laid beside the host.

The egg laying is strongly dependent on the temperature. The number of eggs being laid decreases successively as the reserves of the female are being used up. After a week or two, at a temperature of 25°C the weight of the female decreases because of starvation to 0.3 mg, and she becomes active again and starts wandering around the terrarium.

If she meets a snake she eats again and afterwards goes away and lays eggs again. A female can lay about 60-80 eggs before she dies. She eats two to three times with an interval of one to two weeks. Both the temperature and the humidity influence the life span of the female mites. The life span increases with lower temperature and higher humidity. Food increases the possibility for egg laying for the female but it does not increase her life span. An adult female lives, at the most, about one month at 20°C and 95% RH, at 30°C the life span is 1-2 weeks shorter. At 2°C and 95% RH occasional female mites can survive for more than four weeks, and start laying eggs again when they are placed back at 25°C afterwards. They die within 12 hours at 40°C and 95% RH.

As a summary we can state that with regard to the temperatures that are normally being maintained in most reptile collections (25°C), a complete life cycle of *Ophionyssus natricis* (from egg to egg laying female) takes 2-3 weeks (from 13 to 19 days), and a few individuals live as long as 40 days.

SENSORY BEHAVIOUR

Despite their seemingly intelligent behaviour the snake mites are being governed by their responses to several stimuli. Camins study in 1953 included experiments with the reactions of mites on several physiological parameters.

Temperature

Mites that could choose between temperatures from 9°C to 49°C preferred 20-23°C. Beneath 10°C mites of all developmental phases remained lying still, except fully engorged adult females which could move at a temperature of down to 2°C. The thermal point of death (when all stages of development die within 5 seconds) was being determined at 50-55°C. The speed with which the mites move depends on the temperature. Camin (1953) measured a speed for the quickest phase - adult nonfed females - at 30-40°C of 4.6 mm/sec and at 20-23°C of 1.4 mm/sec. Schroeder got a speed at 37°C of 3 mm/sec and at 19°C of 0.5 mm/sec.

Adult mites can walk nearly continuously for half an hour which moved them 1.35 m at room temperature (19°C) or 2.4 m in a terrarium (31°C) (Schroeder 1934).

Humidity

When the mites could choose between several grades of humidity they chose 95% RH, which earlier proved to be best for the development of eggs and larvae.

Smell

To study a mite's sense of smell it was determined whether they were being drawn to snake blood, snake's faeces or snake skin. For the first two hours they were drawn to snake blood, but after it coagulated they did not prefer anything in particular. In experiments with live snakes, mites of all phases of development were drawn towards the

smell of the snake within 15 minutes. The same experiment was repeated with a snake that was dead for 24 hours and with a mouse, but the mites were not drawn to these.

To find out where the organ of smell was situated in the mites experiments were done with mites whereby several parts of the legs were removed. The result showed that the sense of smell is located in a cluster of sensory hairs at the end of the first pair of legs. In these groups of hairs, several were found to have a club-like form, as chemoreceptors would look.

Gravitation

All phases of mites that meet a surface with an inclination from 5° to a 90°angle want to go up. Full eaten protonymphs and adults are forced to go up because their legs are situated so far on the front of their heavy, full body, and when they go in any other direction but upwards they easily lose their balance and fall.

Contact

Contact is necessary for the mites to be able eat. When the scales of a snake infested with mites are stretched in such a way that the mites are no longer covered, they stop feeding until they have crawled under the scales again.

It appears that mites seldom slough or lay eggs on a snake, with the exception of mites in the corners of the eyes and in some cases under the big ventral scales of a large snake. In these places the mites can - even after they have eaten themselves full - have the biggest part of their body covered and in contact with the snake.

Light

When the mites get to choose between diffuse light and darkness they choose darkness. When they are subjected to a straight horizontal beam of light they go in the opposite direction. If a red filter is placed before the beam of light the mites don't react to that, on the other hand, yellow, green and blue light have the same effect as white light which shows that the colour vision of the snake mites - as with many other insects - does not extend to the longer wave lengths.

When nymphs or adult mites walk, they hold their foremost pair of legs stretched right in front of them and walk with the other three pairs of legs. By removing different parts of the front legs it has been established that the light receptors are situated at the front of the foremost legs.

The larval stages which have only three pairs of legs use all three to walk, and stand still only once in a while whereby they wave their foremost pair of legs to be able to see.

CIRCUMSTANCES IN WILD SNAKES AND CAPTIVE SNAKES RESPECTIVELY

Ophionyssus natricis is a typical sedentary parasite and it has to find a host two times during its development. The mites also have to find a suitable environment two times to change and lay eggs. They lay few eggs and are left behind each time the snake sheds its skin. From these facts one can assume that their host in the wild must be reptiles that repeatedly seek the same spots. These places also have to fulfill the demands which the non-eating phases of the mites require.

In the wild the most heavily mite-infested snake does not harbour more than 100 mites and the mites seem to have a preference for the slits of the eyes and underneath the head scales as feeding places (Yunker 1956, Blanc & Ascione 1959). The strong mite-

infestations with thousands of mites that can be seen on snakes in captivity results from a constant access to the host, together with a larger area on the snake that is accessible for the mite's hunt for food. Because a captive snake with a limited area to move about moves less than a snake in the wild, the mites can look for food on the entire body of the snake, whereas they would be crushed on a wild, more active snake.

DAMAGE TO THE SNAKE

A terrarium snake that can't get away, can become infested with thousands of mites. When a large number of mites suck blood, the loss of blood can become so great that it leads to the snake's death (Camin 1948, Elkan 1973, Schroeder 1964). Camin (1948) showed that strong mite-infestations led to the death of snakes after one to four months. Schroeder (1964) infected ten snakes with mites, whereby all of them died within 16 days.

When the mites suck blood they perforate the snake's skin which can become a gate for bacterial infections (Elkan 1973). Camin (1948) showed that snake mites can transmit the bacterium *Aeromonas hydrophila* from sick to healthy snakes. The healthy snakes are infected and die within a few days of hemorrhagic septicemia (blood poisoning with bleeding in the internal organs) when they are kept in terraria together with sick snakes and snake mites.

Camin assumed that the mites transmitted the infection mechanically when they were eating and that they probably cannot bear the infection for more than 24 to 48 hours. Heywood (1964) also described an outbreak of an *Aeromonas hydrophila*-infection with death resulting from septicemia in some snakes in a zoo, where mites were suspected of being involved in the spreading.

SPREAD OF THE INFESTATION

Because snake mites are very common among snakes in captivity worldwide it is assumed they spread through snakes that are changed between the terraria rather than through wild caught snakes (Camin 1953). For snakes in private terraria in Sweden one can eliminate infestation from wild caught snakes because of an import ban. Probably snake mites are not to be found on wild snakes in Sweden because of our climate with cold winters. Wild caught swedish snakes and mosses that one takes into the terrarium will therefore not pose a risk for mite-infestation.

Snake mites are common among captive snakes in Sweden (own assumption) and the infestation spreads when the snakes change ownership or change terrarium for other reasons. Reptile exhibitions with privately-owned snakes, which are brought together in an exhibition room for some weeks before they are moved home again, are a great risk to the spread of infestations.

When the snake mites have been brought into a reptile collection, they will then easily spread to eventual other snakes and terraria. The mites can easily be transferred between the terraria through the keeper's hands, a spade which is used to remove faeces, objects that are moved between terraria etc. The nymphs are so small that they can be seen with the naked eye only with difficulty, and they can hitch a lift on a person's hands without being noticed. It is also possible for the mites to migrate between the terraria on foot.

DIAGNOSIS

A snake infested with mites often shows signs of irritation and discomfort. It may move about constantly and push and rub itself against objects in the terrarium (Schroeder 1934, Kauffeld 1954). It likes to bathe when it has access to bathing water. Especially when the snake usually does not bathe long it is a dubious sign. A careful examination of the water bowls and the bathing water when it is thrown away often reveals the presence of mites (Kauffeld 1954). The mites drown in water and can be seen as small, about 1 mm big, dark red to black balls (adult full eaten females).

When a snake has mites one can often find them in the corners of the eye. A gentle rolling of the eyes gets the mites to crawl out (Kauffeld 1954). Other places on the snake that the mites seem to prefer are underneath the scales of the chin and near the cloaca (Schroeder 1934, Kauffeld 1954).

The mites one finds on the snake are mostly protonymphs (Yunker 1956). Protonymphs are so small that it is difficult to see them with the naked eye. Adult mites can also be found commonly on the snake. Full eaten adults are so big that they easily can be seen as about 1 mm big dark red to black balls that crawl about. When examining the scales of a snake infested with mites one can see myriads of small, white dots which are the dried droppings of mites. In serious cases the whole snake looks dirty grey and chalky (Kauffeld 1954, Schroeder 1934). An affected snake often also gets a rough, ugly skin and does not slough in one piece (Frank 1981).

CONTROL

If the control of snake mites is to be successful, both the snake and the terrarium have to be treated. Material from the bottom in terraria that seem to be free of mites can contain large quantities of eggs, nymphs, exoskeletons, faeces and adult mites, even if it stood empty for a time (Schroeder 1934).

Sanitation of the terrarium is made more difficult by permanent furnishings. With regard to protection against infection it is best to use such furnishings that can be taken out and destroyed. Snake mites have little or no resistance against a lot of chemicals and the effectiveness of the treatment depends largely on the accuracy with which the cleaning is done (Schroeder 1934).

PHYSICAL MEANS OF CONTROL

Water

The snake can effectively rid itself of the mites it carries by lying immersed in water for a long time (Camin 1948, Kauffeld 1954). If the snake is isolated in a pot of water just before sloughing and the discarded skin is removed as soon as it is laid off the snake can be freed of mites (Kauffeld 1954). Pebbles and stones can be taken out of the terrarium and remain immersed in water for some days.

Sloughing

When a snakes sloughs it leaves behind all mites it carries on the discarded skin. In case the owner helps to remove the skin the mites can be removed. Great accuracy must be observed so the snake cannot be infected again.

Oil
Soaking the snake in different oils or in vaseline can work through suffocation of the mites (Kauffeld 1954), but it has a limited effect (Heywood 1968), and can soften the snake's epithelium and cause skin disorders, e.g. with sloughing (Kauffeld 1954).

Hunger and dehydration
It does not help much to leave a terrarium that is infested with mites unused for a time, because the mites can survive long periods without food according to Elkan (1973). Torsten Mörner (1992, pers. comm.) however, states that two weeks without snakes in a terrarium, with the heating on, frees the terrarium of mites because of starvation and dehydration.

Own experiments showed that a mite population that was isolated in small, tight plastic boxes, with a high humidity, at room temperature without access to food, still contained many live mites after six weeks. The adult females that were isolated laid eggs that developed into larvae and protonymphs, which explains the long life span for the population compared to the life span for each individual phase in development as mentioned by Camin (1953). When all equipment capable of holding moisture is removed and the terrarium gets dry and warm, it can however, be certainly free of mites in a few weeks.

Cold
Freezing of the terrarium - without snakes - or of objects can be an alternative when it is practically possible (e.g. in winter). Schroeder (1934) reports that freezing overnight at -7°C did not kill all mites on a dead mite-infested snake. Freezing for a longer period can still be effective, but it is unknown how much time is necessary (most likely some days).

Foto 1: Mijten rond oog van slang. Mites around a snake's eye. Foto: Irene Ahl.

Warmth
Heat - moist or dry - is always effective (Schroeder 1934). All stages of development die within 5 seconds at 50-55°C (Camin 1953). Hot steam that is sprayed over the walls and objects has a deep penetrating capacity. A blow lamp destroys all life on the surface but the warmth does not penetrate so deep. Schroeder (1934) recommends that the temperature in the entire terrarium is increased to 60°C or more for at least two hours to get the terrarium free of mites. This can be solved practically when one has moveable terraria and has access to a sauna. Possibly, the temperature can also be raised sufficiently with the help of a car heater (beware of the risk of fire in wooden terraria). Remember to take the snakes out of the terrarium before the temperature is increased. Pebbles and stones can be taken out of the terrarium and washed with scalding hot water.

Other
To paint anew all the surfaces in a wooden terrarium is a good measure (Kauffeld 1954). A possible solution to the mite problem for large zoos where mite control is met by many practical problems, could be a mite-eating insect. Schroeder (1934) suggests hunting species of the order *Coleoptera* (beetles).

CHEMICAL MEANS OF CONTROL

Ammonium-fluorosilicate powder.
Present in the preparation Drie-Die SG 67 (Davidson, National Biocide). A 4% ammonium fluorosilicate powder that is being dusted on the snake kills the mites through dehydration. The preparation can be used on large snakes but should be avoided on small snakes because of the risk of dehydration of the snake (Camin *et al* 1964).

Bromocyclen
Belongs to the group of halogenated hydrocarbons. Present in Alugan (Hoechst). A solution of 0.2% can be used (Holt unpubl. according to Holt 1981). Torsten Mörner (1992 pers. comm) recommends bathing the snake in a 2% solution (sic!) while at the same time one should rub against the scales with a sponge to make sure the solution comes under the scales. Afterwards, the terrarium has to stay empty for two weeks, with the heating on, so the mites that remained in the terrarium will die of starvation/dehydration.

According to my own experiences there is no danger to bathe snakes in a 2% solution of Alugan, not even for small snakes. In case the terrarium is cleaned with the same solution and the snakes are placed back immediately afterwards, the treatment has to be repeated 2-3 times with a week in between to be effective.

Derrisroot
An acetone extract of Derrisroot belongs to the plant poisons. It is present in Rotenon. The snake is dipped in a solution of water with Rotenon. The treatment is effective and has a low toxicity according to Schroeder (1934). According to Kauffeld (1954) Rotenon is able to cause poisoning. It is reported that garter snakes and water snakes are extra sensitive.

The snake can also be treated with Rotenon powder. Bathing- and drinking water have to be removed from the terrarium, to avoid poisoning in case the snake should wash the powder off in the water and afterwards drink it. After 48 hours the powder has to be washed off the snake (Kauffeld 1954). The terrarium can be cleaned with a Rotenon solution (Schroeder 1934) or dusted with Rotenon powder which is washed away after 48 hours (Kauffeld 1954).

Diazinon 25-E
Diazinon 25-E (Geigy) belongs to the group of heterocyclic phosphorus derivates. A 1% solution is sprayed in the terrarium and on the reptiles. When necessary the treatment should be repeated after 2-4 weeks. According to Camin *et al* (1964) and Holt (1981) the treatment seems safe, even for small reptiles. But there are reports about the death of two *Morelia spilotes variegata* in connection with a treatment with a 0.05% solution of Diazinon (Heywood 1968) and two *Cyclagras gigas* after they were dipped in a 0.07% solution, in spite of the fact they were immediately doused with water (verbally from R.J. Greer 1975 according to Marcus 1981).

Dichlorvos
Belongs to the group of organic phosphor compounds. It is sold in the form of plastic blocks with trademarks like Mafustrip, Sektivap or Vapona strip (Shell). The plastic block is put in the desired room where it gives off dichlorvos to the air. 0.6 cm Vapona strip per 0.28 m^3 terrarium can be left together with the animal for up to four days. Without the animal the same amount can remain in the terrarium for ten days.

A Vapona strip in a room of ß28 m^3 can be used continuously (Holt 1981). The treatment is not without risk, especially for small reptiles. There are reports of deaths (Jackson 1974, Bush 1974 according to Holt 1981). It is reported that dichlorvos causes paralysis in Anolis lizards (Marcus 1981). There are reports about resistance to dichlorvos in snake mites (Todd 1983 according to Lawrence 1984).

Ivermectin
Belongs to the group of macrocyclic lactones. Present in Ivomec (MSD/Pherrovet). An injection of 200 µg/kg body weight (1% w/v solution) subcutaneously (under the skin) on the middle third part of the body has shown the snakes to be free of mites within 48 hours. For small snakes the solution can be diluted with 9 parts water to facilitate the dosage (in spite of the fact that Ivermectin is not soluble in water). Only the feeding stages of the mites are killed and the treatment must be supplemented with another method to combat the mites in the terrarium and furnishings (Lawrence 1984).

Metrifonate
Belongs to the group of organic phosphor compounds. Present in Neguvon (Bayer). According to Heywood (1968) a 0.15% solution in water is safe and effective. Cooper (1973) reports no toxic effects with snakes when spraying with a 1% solution each 4-6 weeks. Harry Kuusisto (1992 pers. comm.) says that spraying snakes and terraria with a 0.2% solution 2-3 times with some weeks in between is effective and safe. A study done by Lehmann (1969) showed that Neguvon had the best egg-killing (ovicidal) effect of several different preparations. 100% of the mite eggs were killed. The preparation does not have any damaging effect on different tropical plants that may be present in the terrarium (Lehmann 1969).

But Neguvon also can cause poisoning and death in snakes. Two rattlesnakes died within a week after being dipped in a 3% solution (Magnus Forsberg 1992 pers. comm). Several cases of poisoning in snakes have been described by Lehmann (1969). Some snakes showed signs of poisoning like coordination difficulties and paralysis. Several juvenile snakes died while others spontaneously recovered.

After experiments Lehmann comes to the conclusion that juvenile snakes are not more sensitive to Neguvon than adults. Poisoning is not common in normal reptiles but can be expected in sick, thin or weak animals (Lehmann 1969). Metrifonate penetrates undamaged skin (FASS VET 1992). Bathing or spraying therefore, bears a risk that the snake absorbs

the substance and is poisoned. The risk can be greater for a snake with a lot of small skin sores after mite bites. A small snake has a larger body surface compared to its body weight than a large snake, and therefore one can expect it absorbs a higher concentration of Neguvon when it is bathed, with an increased risk of poisoning. Many species of snakes drink the water drops on their own body and in that way they can swallow the substance after Neguvon has been sprayed.

One can eliminate the risk of poisoning with reptiles when one changes to dry-treatment. Cloth bags are impregnated in a 0.2% solution of Neguvon and are left drying. The reptiles are placed in the bags for about four hours. In the meantime the terraria are sprayed with a 0.2% solution of Neguvon, ½-1 liter per m^3 terrarium. When the terrarium is dry the reptiles are placed back (Lehmann 1970). According to my own experiences this treatment is effective and safe, also for very small snakes. It might be necessary to repeat the treatment two to three times with a 10-14 days' interval. Neguvon has a good lingering effect. After up to 10 weeks the cellulose that was dipped in a Neguvon solution contained sufficient active substance to kill snake mites within 24 hours (Lehmann 1969). When snakes get poisoned by Neguvon a treatment can be tried with water perorally (probe via the mouth) and a sodium chloride solution parenterally (injected in the abdominal cavity or under the skin) combined with baths for several days, to increase the secretion of Neguvon (Lehmann 1970).

Foto 2: Behandeling tegen mijten door een bad in een ontsmettingsmiddel. Treatment against mites by bathing in a control agent. Foto: Irene Ahl.

Ortho Dibrom 8-E

Ortho Dibrom 8-E (California Chemical Co.) belongs to the group of aliphatic phosphor derivates. 0.5-1 ml per liter water is sprayed on the snakes and in the

terrarium. When necessary the treatment should be repeated after 2-4 weeks (Holt 1981). The treatment is said to be safe, also for small reptiles (Camin *et al* 1964).

Pyretrines

Present in dog shampoos against fleas and lice, Canitex, Dermocan (AB Dogman). Two tablespoons in two liter water can be used to bathe snakes and clean terraria.

The treatment should be repeated two to three times with an interval of three days (Jimmy Magnusson 1992 pers. comm). This treatment does not hold much risk for the animals but is probably not so effective and requires persistence with the execution.

RECOMMENDATIONS FOR TREATMENT

The method that is chosen depends a great deal on the number of snakes that have been affected and the type of terraria, together with a thought to how much work can be done and which risks can be taken.

A bath for the snake, preferably on the same time as a slough, and a heat-treatment of the terrarium or leaving it empty for some weeks does not bear any risk of poisoning at all, but can be difficult to arrange practically.

Of the above mentioned chemical means of control I myself had the best experience with Neguvon, but one should be conscious of the fact that Neguvon is a strong poison. It is only given on prescription, and must be prescribed by veterinarians. When handling Neguvon one should wear protective clothing, gloves and a breathing mask.

The effective substance metrifonate penetrates the undamaged skin and can also cause poisoning in humans. Wash with soap and water if the preparation has come into contact with the skin.

Spraying should be done with low pressure (not vaporizing) to avoid inhalation (FASS VET 1992). To be safe, one should leave the execution of the treatment to someone else if one is pregnant.

When making a Neguvon solution one should use warm water with a temperature of 40°C. A new solution has to be made for every new treatment because metrifonate is instable in water. The time in which it breaks down in a solution of water depends on the pH. With a pH 7 the effective component has been reduced to 50% after 6.5 hours. With a pH 8 the same happens in an hour, whilst with a pH 6 it takes 87 hours (Eva Skiöldebrand, Bayer, 1992 pers. comm.) That means in a practical sense that a solution of Neguvon in water should be used within two to three hours to get the expected result.

A more simple alternative to a treatment with Neguvon can be a treatment with dichlorvos. The disadvantage with dichlorvos which is given off to the air, is the fact that it is hard to dose. An overdose can lead to the death of the reptiles and an underdose can lead to the development of resistance in the mites.

The amount of dichlorvos that is given off in the air by a dichlorvos-impregnated plastic block decreases with time and it is difficult to know when it has become so low that is has become without effect or worse, helps the mites to build up resistance against it. If one chooses to sanitate the terraria without animals with dichlorvos - preferably use a new pack and treat the animals with another method - the dosage can be increased for a better effect. Neither Mafustrip, Sektivap nor Vapona strip are sold in Sweden.

PROPHYLAXIS

The best way to avoid an infection with mites is to keep newly bought snakes in quarantine. Kauffeld (1954) recommends a quarantine of three to four weeks. During this time the new snake should be inspected extra carefully to discover an eventual infection with mites. A terrarium with mite-infested snakes or a quarantine terrarium with a risk of mite-infested snakes can be isolated by putting a strip of vaseline around the terrarium or a trench filled with water to avoid a spread of the mites (Schroeder 1934, Camin 1948).

Snakes that have been to an exhibition with a risk of infection should also be kept in quarantine on their home-coming. Cooper (1973) sprays as a precaution all snakes that are newcomers to the Nairobi Snake Park with a 1% Neguvon solution. According to Lehmann (1970), a preventive dry-treatment with Neguvon is a better alternative and can be used routinely on all newly arrived snakes.

Besides, there are other reasons to keep new snakes in quarantine. To prevent the mites from spreading between terraria one should wash hands and instruments between each terrarium. The instruments can be dipped in a disinfectant solution - e.g. chlorine - between each terrarium (Kauffeld 1954).

To decrease the number of mites in terraria that are already infected (in expectation of sanitation) one has to remove discarded skins as quickly as possible (Kauffeld 1954). White flannel cloths can be put in the terrarium overnight, the cloths attract mites which can be removed each morning (Schroeder 1934).

SNAKE MITES ON HUMANS

There are reports of people who were affected by snake mites. In those cases they were people who had been in very close contact with mite-infested snakes. Camin (1953) describes that mites were often feeding on him when he was doing his temperature experiments and the temperature in the room was below 15°C.

Privora (1958) describes how laboratory personnel in a toxin laboratory got a red, vaguely defined rash on their hands when handling mite-infested snakes. The rash was interpreted to be an allergy. Schultz (1975) describes a case of a family who got an itchy, rough, fluid-filled rash after they had acquired a two meter long 'pet python" which they often carried around. Snake mites were discovered on the snake and on the members of the family. The problem disappeared when the snake was treated.

REFERENCES

Blanc, G. & L. Ascione, 1959. Sur la Présence d'*Ophionyssus natricis* (Gervais 1844) sur Trois Serpents du Maroc des Forêts de Nefifik et du Cherrat - Arch. Int. Pasteur Maroc 5: 666-668.

Bush, M., 1974. Am. Ass. Zoo. Vet. Ann. Procs., USA: 68-78.

Camin, J.H., 1948. Mite Transmission of a Hemorrhagic Septicemia in Snakes. J. Parasitol., 34: 345-354.

---, 1949. An Attempt to Clarify the Status of the Species in the Genus *Ophionyssus* Mégnin (Acarina: Macronyssidae). J. Parasitol., 35: 583-589.

---, 1953. Observation on the Life History and Sensory Behavior of the Snake Mite, *Ohionyssus natricis* (Gervais) (Acarina: Macronyssidae). Chicago Acad. Sci., Spec. Publ., 10: 1-75.

Camin, J.H. *et al*, 1964. Control of the Snake Mite, *Ophionyssus natricis* (gervais), in Captive Reptile Collections. Zoologica, 49: 65-70.

Cooper, J.E., 1973. Veterinary aspects of recently captured snakes. Br. J. Herpetol., 5: 368-374.

Elkan, E., 1973. Mites Killing a Snake. Br. J. Herpetol., 5: 344-346.

Frank, W., 1981. Ectoparasites in 'Diseases of the reptilia' (Cooper J.E. & Jackson O.F. eds.), Vol. 1: 359-383. Academic press, New York and London.

Hirst, S., 1915. On a Blood-sucking Gamasid Mite (*Ichoronyssus serpentium*, sp. n.?), parasitic on Couper's Snake. Proc. Zool. Soc. London: 383-386.

Heywood, R., 1968. Aeromonas infection in snakes. Cornell Vet., 58: 236-241.

Holt, P.E., 1981. Drugs and Dosages in 'Diseases of the Reptilia" (Cooper J.E. & Jackson O.F. eds.), Vol. 2: 551-584.

Jackson, O.F., 1974. Vet. Rec., 95: 11-13.

Kauffeld, C.F., 1954: Mites and Ticks in Captive Snakes with remarks on Cage Sanitation. Herpetologica, 10: 103-107.

Lawrence, K., 1984. Ivermectin as an ectoparasiticide in snakes. Vet. Rec., 115: 441-442.

Lehmann, H.D., 1069. The value of Neguvon and other Insecticides in the control of Ectoparasites in Terrarium Animals. Salamandra, 5: 1-14. Author's abstract.

---, 1970. Über den Wert von Neguvon und anderen Insektiziden für die Bekämpfung von Ektoparasiten bei Terrarientieren. Sonderdruck aus Veterinär-Medizinische Nachrichten, 3: 227-229.

Marcus, L.C., 1981. Veterinary Biology and Medicine of Captive Amphibians and Reptiles, 168-171, 196-197. Lea & Febiger, Philadelphia.

Radford, C.D., 1950. The mites (Acarina) parasitic on mammals, birds and reptiles. Parasitology, 40: 366-394.

Reichenbach-Klinke, H. & E. Elkan, 1975. The Principal Diseases of Lower Vertebrates, Book III, Diseases of Reptiles, 474-495. T.F.H. Publ. Neptune City.

Schroeder, C.R., 1934. The Snake Mite (*Ophionyssus serpentium* Hirst). J. Econ. Entom., 28: 1004-1014.

Schultz, H., 1975. Human infestation by *Ophionyssus natricis* snake mite. Br. J. Dermatol., 93: 695-697.

Stammer, H.J., 1957. Beiträge zur Systematik und Ökologie mitteleuropäischer Acarina. Aus dem zoologischen Institut der Friedrich Alexander Universität erlangen. Band I: Tyroglyphidae und Tarsonemini, Teil I. Leipzig.

Till, W.M., 1967. Mesostigmatic mites living as parasites of reptiles in the Ethiopian region (Acarina: Laelaptidae). J. Ent. Soc. S. Africa, Vol. 20 (1): 120-143.

Todd, S., 1983. Herptile, 8: 90.

Wallach, J.D., 1969. Medical Care of Reptiles. J. Am. vet. med. Ass, 155: 1017-103.

Yunker, C.E., 1956. Studies on the Snake Mite, *Ophionyssus natricis* in nature. Science, 124: 979-980.

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