THERMOREGULATION OF THE ADDER, *VIPERA BERUS BERUS* (L.).

By: Hans van der Rijst, Wolweverslaan 38, De Meern, The Netherlands.

Contents: Introduction - The spring - The summer - References.

INTRODUCTION

Adders are cold blooded (poikilotherm) animals. Their preferred temperature is about 30°C, a little higher when digesting prey. It is interesting to know how they reach and maintain this temperature in nature. This is one of the subjects on which research has been carried out for four years in the northwest Veluwe, The Netherlands (Lamberts & Van der Rijst, 1988). This article presents the results of that research in a shortened form.
Poikilotherm animals thermoregulate by absorbing and at the same time losing energy to their surroundings. When they absorb more energy than they lose, then they are warming up and vice versa. Adders collect energy by absorbing the radiation of the sun and by convection via air and substrate. The lose of energy principally occurs via convection. We will look at the thermoregulating behaviour of Adders in the spring as well as in the summer.

THE SPRING

When an Adder warms itself in relatively cold but clear weather, most of the energy comes from radiation. At the same time with

this type of weather the Adder will lose much warmth by convection. This of course is not good for the process of warming up, therefore the lose of warmth by convection in this situation has to be prevented as much as possible. Adders are principally found on slopes overgrown with *Deschampsia flexuosa*, a type of grass, where they lay between clumps. In this way they lay on a slope and within a little dip. Inside this dip the wind is tempered, so that the warmed air stays within the dip. The layer of air directly around the Adder (only a few mm thick) is of great importance as this air determines how much warmth is lost to the air by convection. The bigger the difference in temperature between the Adder and the layer of the air, the more warmth is lost. As the Adder lays in a calm spot, an isolating layer of air is formed around her, and this limits the lose of warmth. Also via the substrate on which the Adder rests warmth flows away. *Deschampsia flexuosa* is a type of grass that stays green all year round. In spring, however, there are present dead plucks of grass. The surface temperature of this dead material proves to be higher than that of living leaves. The temperature of living leaves is principally determined by the speed of the transpiration. When the stomata are normally opened, the temperature of the leaves hardly differs from the temperature of the surrounding air. When the stomata are closed, however, then at full sunlight the temperature of the leaves can rise to more than 10°C above that of the air (Lambers, 1986). Dead *Deschampsia flexuosa* does not transpire for which reason alone the temperature of the surface already will be higher than that of living plants. A second character of dead material is that the albedo is

lower than that of living material. The albedo gives the percentage of the received radiation of the sun that is reflected. Material with a low albedo reflects less radiation. This means that it absorbs radiation by which reason the temperature of it rises. It was observed that Adders were laying on dead material, while only a few centimeters away the conditions seemed exactly the same, except for the dead grass. So it strongly creates the impression that Adders knowingly look for these spots with a higher surface temperature. This hypothesis has been tested within outdoor terraria. The Adders were offered a spot for sunbathing, of which one part had a surface temperature of 25°C and the other part of 30°C. This was achieved by digging in two jerrycans under the sunbathing spot: one of the jerrycans was filled with water, the other with air. The upper surface of both jerrycans was smeared with glue and sprinkled with sand. The temperature above the jerrycan with water did not rise over 25°C, while the surface temperature above the jerrycan with air rose to 30°C. In total 122 observations were made: the Adders were sunbathing 109 times on the "warm" spot and 13 times on the "cold" spot. So we can conclude that Adders, when the weather is relatively cold and the temperature in the shadow is maximal 18°C, prefer sunbathing on a substrate with a higher surface temperature. The result of this is that the difference in temperature is diminished resulting in a decreased lose of warmth. So the Adders lay in a dip and on dead material. Additionally they lay on a slope, to receive sunbeams as effective as possible. Under an angle of 90 degrees per surface-unit most sunbeams are received. In spring and in autumn the sun is in the sky at a

lower angle and so the Adder receives the sunbeams most effective when she is laying on a slope. Not only does the Adder receive radiation effectively but also the slope itself becomes warmer under an angle. In this way the surface temperature of the substrate also rises, which reduces further lose of warmth by convection.
Besides the optimum use of the micro climate the Adder regulates his temperature by means of body posture. In most cases the animal starts the sunbathing behaviour by laying stretched out and with a flattened body. Through this posture the surface with which the radiation can be received is enlarged. At the same time, however, through this posture the lose of warmth by means of convection increases. So the Adder will only use this posture when there is a positive energy balance between the receiving of warmth by radiation and the losing of warmth by convection. When the amount of radiation for a positive energy balance decreases, she coils herself up. In doing so she will coil up tightly or in loose coils, depending on the circumstances. Early in the spring, during uncertain weather, it is possible that after a sunny period it may suddenly snow a little bit or hail or rain. During such a shower the Adder coils up as tight as possible. By doing so she reduces the surface of her body that is in contact with the substrate and the air, thus reducing the lose of warmth. The surface of the body can be reduced even further by looking for congeners and forming a cluster. This phenomenon can be observed regularly during the spring. After a shower the Adders unroll and again stretch themselves in the sunshine with flattened bodies. The following example demonstrates the great influence of this

active sunbathing behaviour. In heavy clouded weather there are often periods of

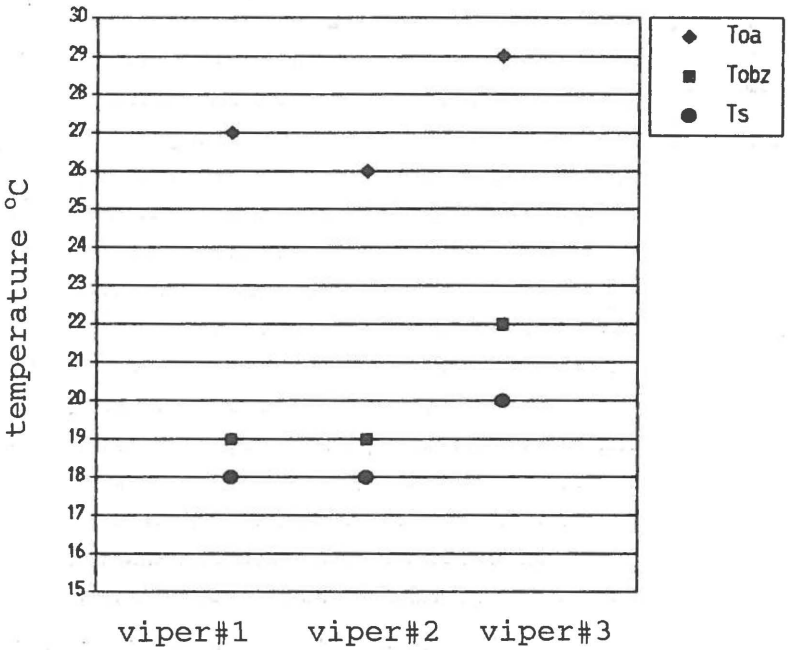

Figure 1:
Temperatures measured at heavy clouded weather. Ts = shadow temperature measured 1 cm above the substrate; Tobz = surface temperature of the substrate on which the Adder was laying; Toa = surface temperature of the body of the Adder.

thinner cloud-cover, which results in a temporarily increase of intensity in the radiation. When this happens the Adders react by stretching out and flattening their bodies. At a decrease of the intensity of the radiation they roll up again. In figure 1 three temperatures are showed: The shadow temperature 1 cm above the surface; the surface temperature of the substrate on

what the Adder was laying and the surface temperature of the Adder herself. These temperatures have been measured during the above described weather near and at the sunbathing spot of three Adders. The surface temperature of the substrate was 1 to 2°C higher than that of the air, while the surface temperature of the Adders was 8 to 9°C higher! Dead material has a very low albedo. This means that when an Adder sunbaths passively, her surface temperature cannot become much higher than that of the dead material. However, by active thermoregulation and by physiological adaptations (Schiereck, 1989), the Adder is able to raise her body temperature several degrees centigrade even in heavy clouded weather.

THE SUMMER

During the end of spring (mid May) and during the summer almost no Adders were found sunbathing. But of course the Adders continue to thermoregulate. How they do this? After mid April the amount of received radiation of sunlight per unit of time increases. The average maximum day temperature also increases. These two factors together make it easier for the Adder to reach its optimum temperature. The duration of time that we find the Adder sunbathing decreases for this reason. During the study, however, it was found that the Adder continues to thermoregulate; not on the vegetation but underneath. This has two advantages. First the Adder is less visible to his most important predators (the birds). An Adder always tries to sunbath as sheltered as possible: protected from above, near hiding places, etc. There is no doubt

that protection is at an optimum when the Adder is under the grass. The second advantage concerns thermoregulation. Sunbathing in the open air results in the temperature of the Adder becoming too high too soon, while entirely in the shadow is too cold. One possibility is that the Adder starts shuttling between sunny and shady spots. However, this has disadvantages: it costs, relatively, a lot of energy and, the Adder is more visible to his predators. This behaviour was not observed in the field. But what I did observe was that the Adders lay under the grass. The result of the hanging grass leaves is that much light is stopped. Research on *Deschampsia flexuosa* showed that the temperature between the grass decreases at lower levels (Barkman & Stoutjesdijk, 1987; Lamberts & Van der Rijst, 1988). Close to the ground the measured air temperature is usually lower than the air temperature above the grass, while the intensity of the radiation decreases as much as 99%. So when an Adder lays hidden deep under the *Deschampsia flexuosa* he receives very little radiation and the air temperature is lower than above the grass, such that on a sunny day the temperature does not rise higher than 25 to 27°C. On a level between the vegetation (a few cm higher) the Adder receives more direct radiation and the air temperature is higher. So by vertical migration the Adder is able to thermoregulate. These vertical movements have not been observed in the field other than that the Adders were found under the grass at different heights. To make such thermoregulation possible it is necessary that the grass has a certain height and a loose structure. This is only the case with not-trampled-down *Deschampsia flexuosa*. When a person, even only once, walks

over this grass species, the effect is still visible a year later. The grass is pressed down and recovers very slowly. The elasticity of *Deschampsia flexuosa* is minimal. For the Adder this can have disastrous consequences. In the research area it was found that people usually use the same spots as the Adders to sunbath. Often these spots are less than a meter from each other. Happily the Adders are usually found along the edge of a wood while the people lay a meter or more down from the wood. But the possibility that the people change the structure of the grass where the Adders sunbath is quite real. In young tree plantations the chance is even greater. Practically every spot where a person was sunbathing was a possible sunbathing spot for an Adder. With the accent on "was". It has been recorded that certain good spots for sunbathing were not used by the Adders after a visit by people. The grass was trampled down and after one year had not recovered enough. The studied young tree plantations only had three or four good and five to ten less suitable sunbathing spots. The good spots are especially of great importance for pregnant females as they find enough sun hours on these spots only. When per year one or two of these are used (and so destroyed) by people, you can imagine what the result is for the Adder population ...

REFERENCES

Barkman, J.J. & Ph. Stoutjesdijk, (1987), Microklimaat, vegetatie en fauna. Pudoc Wageningen.

Lambers, J.T., (1986), Oecofysiologie.

Vakgroep Botanische Oecologie, R.U. Utrecht.

Lamberts, J. & J. van der Rijst, (1988), Een oecologische studie van de adder, *Vipera berus berus* (L.) nabij Ermelo. Afdeling Dieroecologie, K.U. Nijmegen.

Lamberts, J & J. Van der Rijst, (1988), Vergelijkend oecologisch onderzoek naar de structuur en het microklimaat van *Deschampsia flexuosa* in het bos en veld. Vakgroep Botansiche Oecologie. R.U. Utrecht.

Schiereck, P.,(1989), Thermoregulation in snakes. Lit. Serp. Vol. 9 (4), pag 165-176.

Translation: Anton van Woerkom.