

ALBINISM AND LEUCISM AMONG EUROPEAN VIPERINAE: A REVIEW

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The records of albino, partial albino, and leucistic individuals among four species of European Viperinae (*Vipera ammodytes*, *Vipera aspis*, *Vipera seoanei*, and *Vipera berus*) were summarized based on literature records, museum material, reports of field herpetologists and herpetoculturists, and a short description of all reported specimens was made. For the first three species only scattered observations have been made (1, 1, and 6 reports), whereas at *Vipera berus* these defects proved to be more widespread (16 reports), and present an occurrence pattern shift to the Nordic countries. Different hypotheses are postulated on the offset geographic distribution pattern of albinism and leucism at this species, taking into account the differences in predation pressure and population densities between populations in Southern and Northern Europe. The possible negative effect of the color defects on the fitness and survival of the specimens carrying them is debated.

Keywords: *Vipera ammodytes*, *Vipera aspis*, *Vipera seoanei*, *Vipera berus*, fitness, survival.

INTRODUCTION

A huge variety of colors arranged in diverse patterns can be found in snakes. These patterns have evolved for survival value, and their function includes: thermoregulation, protection of vital organs, warning, concealment, mimicry, camouflage, and aid in vision (Jackson et al., 1976; Bechtel, 1978, 1991). Inherited color defects, such as albinism and leucism, are well known in several animal species including snakes (Bechtel, 1991). The proximate cause of albinism is generally attributed to lack of activity of the enzyme tyrosinase, a key component of the pathway leading to the formation of melanin. Leucistic snakes have a diminished number of iridophores and probably very low number or no melanophores and xanthophores (Bechtel, 1991). Deficiencies in the sensory and nervous system and metabolism are associated with the albino state in mammals and several physiological anomalies may also occur (Creel, 1980). The negative effect of albinism on fitness is documented as well (e.g., Lee and Grant, 1986; Møller and Mousseau, 2001). Studies on amphibians, however, did not corroborate these results (Corn, 1986). Mechanisms leading to loss or decrease of tyrosinase activity in snakes have not been elucidated, but presumably this failure is associ-

ated with other deficiencies, similar the ones observed in mammals, which will affect the survival chances of individuals carrying them.

According to Sazima and di-Bernado (1991) albinism seems to occur primarily in snake species that are either cryptozoic, or are well defended (i.e., venomous). Albinotic and leucistic individuals are less common in nature, but are popular and intentionally selected by herpetoculturists, who breed color variants of several species of Pythonidae and Colubridae (Bechtel, 1995).

Among the European Viperinae individuals with color defects have been reported so far at three species: *Vipera ammodytes* (Ripa, 1997), *V. aspis* (Coborn, 1991; Matz, 1994; Naulleau, 1997), and *V. berus* (e.g., Leighton, 1901; Vainio, 1931; Edelstam, 1971; Bruno, 1985).

The purpose of this note is to summarize the records from literature, specimens in different museum collections, observations of field herpetologists and herpetoculturists. Also discussed are the geographic distribution pattern of albinism and leucism for *V. berus*, and the possible negative effect of these color defects on the fitness and survival of the individuals carrying them.

MATERIAL AND METHODS

Data were gathered by surveying the literature focused on European Viperinae since 1900. More recent records were also obtained from herpetologists and her-

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petoculturists. Additionally, the *V. berus* collection of all major European museums were surveyed and the albinistic and leucistic specimens were noted.

For all individuals the type of color defect was recorded, together with locality data, collector or source of the information, data on the dorsal pattern (visible or not), ground color, color of the eyes. Where possible, other important details, such as date of the observation, length of the individual and exact collection records were provided as well.

Additionally all other reports, where the exact number of individuals or the collection records were not known have also been included in the list.

RESULTS

Table 1 gives a complete account of the records of albino, partial albino and leucistic individuals observed among European Viperinae.

I have been able to add one more species, *V. seoanei*, to the known three (i.e., *V. ammodytes*, *V. aspis*, and *V. berus*) where albinistic specimens occur.

Three albino individuals have been found in the herpetological collection of the Swedish Museum of Natural History (Naturhistoriska riksmuseet), Stockholm (NRM), Zoological Museum of the University of Turku (ZMUT), and Zoological Museum, University of Copenhagen (ZMUC).

Information on 24 individuals carrying these defects were collected. For *V. ammodytes*, *V. seoanei*, and *V. aspis* only scattered observations have been made (1, 1, and 6). For *V. berus* 16 albinistic and leucistic specimens were found, intimating that the mutations are more widespread at this species. Additionally they present an occurrence pattern shift to the Nordic countries (10 records come from this area). As the majority of reports come from individuals of *V. berus*, the hypotheses will be based only on these ones.

DISCUSSION

In general, albinos have low survival rates and are removed from the populations rapidly (Møller and Mousseau, 2001; Caro, 2005). The negative effect of albinism on fitness was documented for birds (e.g., Lee and Grant, 1986; Møller and Mousseau, 2001) and mammals (Laikre et al., 1996; Caro, 2005). The association of stillborns and malformed individuals with color defects observed among Viperinae support the negative effect of these mutations.

The exact age of a snake cannot be set based on metric data, as the growth pattern is not linear. This is influenced by food availability, environmental stress and population density (e.g., Prestt, 1971; Andrén and Nilson, 1983; Lindell, 1997). Still, where the lengths of the individuals are known, none of these can be regarded a neonate, if we accept the results of Prestt (1971): mean length of *V. berus* at birth is 142 mm in males (range 121–161 mm) and 147 in females (range 125–200 mm). The length of the neonates might differ slightly between different areas, but in general, there should not be large deviations from these values. Thus, all these *V. berus* individuals have over-wintered at least once. The collected records sustain Bruno's (1985) statement that albinistic individuals are more common on the Islands of Scandinavia *sensu lato* (Bruno did not define the area, but probably included the Baltic States as well). The high percentage (62.5% of the records) of specimens with color defects in this region suggests a weaker selection against these individuals. The result can not be regarded a collecting artifact as significantly higher number of field herpetologists and herpetoculturists have been acting in Western Europe than Baltic states and Scandinavia (Adler, 1989). This finding is inconsistent with the alternative climate/thermal capability hypothesis (i.e., selection against albino or leucistic individuals because they are unable to thermoregulate properly). Dark color of snakes was proved to result in a better heat gain than white (Gibson and Falls, 1979). Melanin protects the internal organs from deleterious solar radiation and functions in thermoregulation (Bechtel, 1978). The xanthophores and iridophores are unaffected by the albino mutation, thus they will determine the color of the snake. In "normally" colored snakes red and yellow colors have little physiological role (Bechtel, 1978). However much more yellow pigment is found in albino frogs as in normally colored ones, and this might be a compensatory response, probably to protect it from the solar radiation (Bagnara and Ferris, 1971). If we accept that majority of the individuals mentioned survived for at least one year, the observations of Bagnara and Ferris (1971) that yellow pigment may play a photoprotective role, seem to be apposite for albino snakes as well. These individuals might try to gain heat by being partially sheltered. By a shortening of the time spent exposed, the susceptibility to visually guided predators is also decreased. Still if they choose this alternative, they will need a longer time to gain the necessary heat to be able to search for prey or mates, considering their slow heating rate and weak thermoregulatory efficiency as well. Thus their chances to find food or mates will be lowered.

TABLE 1. Records of Individuals with Color Defects

Species	Defect	Locality	Reference	Dorsal pattern	Ground color	Color of eyes	Remarks
<i>V. ammodytes</i>	a	Bolzano, N. Italy	van Issem (personal communication)	v	pinkish	red	Stillborn, from gravid female collected Born in 2003
<i>V. ammodytes</i>	pa	—	Ripa (1997)	—	—	—	Cage reared juveniles
<i>V. seoanei</i>	pa	—	Mulder (personal communication)	v	pinkish	red	Cage reared, survived a half year
<i>V. aspis</i>	a	—	Matz (1994) record adopted by Coborn (1991) and Naulleau (1997)	v	pinkish	red	Cage reared juvenile
<i>V. aspis</i>	a	—	Naulleau (1997)	—	—	—	One cage reared specimen, mother from the surroundings of Metz, N. France, father from the Island of Oléron, W. France
<i>V. aspis</i>	pa	—	Möller (personal communication)	v	yellowish	brown	Two cage reared juveniles (born in 2004) from parents collected in the Region Creuze, Central France
<i>V. aspis</i>	l	Jura, Switzerland	van Issem (personal communication)	nv	yellowish	yellow	Juvenile, observed in 2003
<i>V. aspis</i>	l	S.-W. Switzerland	Billing (personal communication)	nv	yellowish	yellowish	Juvenile, observed in 2004
<i>V. berus</i>	a	Riihimäki, S Finland	Vainio (1931)	nv(5), v(1)	white	—	Six albino specimens
<i>V. berus</i>	a	Island Nauvo Matnäs, S. Finland	Bruno (1985)	v	pinkish (?)	—	Juvenile male, 190 mm long. ZMUT Se.30, <i>Vipera berus</i> , 1 Albino ex., Nauvo Matnäs, 66829, 2110, 07/01/1997, Leg: Eila Holopaine
<i>V. berus</i>	pa	Island Saaremaa, W. Estonia	Bruno (1985)	v	white (?)	—	Juvenile female
<i>V. berus</i>	a	Island of Öland, Sweden	Edelstam (1971) record erroneously referred to as Island Götland (Bruno 1985: Pl. 8 Fig. 14)	nv	white	red	Adult female, length 570 mm
<i>V. berus</i>	a	Långbanshyttan, Värmland, Sweden	—	nv	white	—	240 mm long, two headed male. NRM 30015. <i>Vipera berus</i> , Långbanshyttan, Värmland, Sweden. Died in captivity (in Stockholm). Leg. Notini G, 11/24/1948
<i>V. berus</i>	a or l	Scandinavia	—	nv	white	—	270 mm long female. ZMUC R. 68138, <i>Vipera berus</i> (L.) var. <i>albus</i> , Leg.: Prof. Schmidt, Source: Studiensammlung, Det.: 01/20/1938, 132
<i>V. berus</i>	a	Garway Hill, Herefordshire, U.K.	Leighton (1901)	nv	white	—	—
<i>V. berus</i>	a	U.K.	Leighton (1901)	v	yellowish	—	Two pickled individuals in the anatomical museum of the Edinburgh University. They may still be housed there
<i>V. berus</i>	a	Hembury Fort, South-East Devon, U.K.	Harris (1936)	v	white	—	One individual seen in 1934
<i>V. berus</i>	a	Dartmoor, Devon, U.K.	Cole (personal communication)	v	pinkish	brown	Found in the 1980s, survived in captivity until 1994
<i>V. berus</i>	pa	Raschau, Erzgebirge, Germany	Oehme (1969)	v	white	—	—
<i>V. berus</i>	a or l	Spandau-Berlin, Germany	Buchner (1917)	nv	yellowish	—	Collected in 1856 by Günther and once stored in the Natural History Museum in Stuttgart, by now is lost (Kwet, personal communication)
<i>V. berus</i>	a and pa	without exact locality records	Wettstein (1929), Trutnau (1975), Schiemenz (1987), Trutnau (1990), Schiemenz et al. (1996)	—	—	—	—

Note. a, albino; pa, partial albino; l, leucistic; v, visible; nv, not visible

An explanation for the higher survival rate of albinistic and leucistic *V. berus* individuals in the northern countries comparing to southern areas might lie in differences in predation pressure. The exact number of adder predators at different localities is not exactly known, but reports on potential predators are available at some populations. Andrén (1985) reported 5 bird and one mammal species on the Island Stora Hästholmen, southwestern Sweden as potential predators of the local population; Monney (1996) 1 reptile, 8 bird, and 1 mammal species at Oberland bernois, Switzerland; 1 reptile, 7 bird, and 9 mammal species can be considered predators in Northern Bavaria, Germany and 1 reptile, 9 bird, and 6 mammal species in one population in Southern Bavaria, Germany (Völkl, personal communication); at the Baláta native moor, Somogy District, Southern Hungary 1 reptile, 24 bird, and 4 mammal species could be mentioned (based on Kasza and Marián, 2001). It is not known whether the intensity of the mammalian predation or predation by birds has the greatest effect, as due to experimental design problems only the latter was tested (e.g., Andrén and Nilson, 1981; Wüster et al., 2004). The number of mammalian predators is larger on the mainland compared to the islands, and they might also be more common on islands closer to the shore compared to more isolated islands (Forsman, personal communication). The avian predation is a more complex question, as many migrating birds pass through the islands in spring and autumn, thus in the mating period of adders and birth of juveniles, but do not spend the summer in these areas (Forsman, 1995). The proportion of individuals with scars, resulting from escapes from predation attempts, was found to be significantly higher at an inland locality than on islands of the Swedish east coast in the Baltic Sea, presumably reflecting a larger number of predators at the inland localities (Forsman, 1995). The dorsal zigzag band of adders is either cryptic, and functions to confuse visually hunting predators by inducing “flicker-fusion” (Shine and Madsen, 1994; Lindell and Forsman, 1996), or has an aposematic effect, which is perceived by avian predators and avoided (Wüster et al., 2004). Normally colored, thus zigzag banded, males survived significantly better than the melanistic ones (Andrén and Nilson, 1981; Lindell and Forsman, 1996). The results are also sustained by model experiments carried out recently by Wüster et al. (2004). In females the situation seems to be reversed; the melanistic ones have higher survival rate (Forsman, 1995; Lindell and Forsman, 1996), the findings being inconsistent with the aposematic effect of the pattern. Albinistic specimen, with no or just slightly visible yellowish or reddish pattern will most probably not be

avoided by avian predators as they are not recognized as a specific viper. They are also unable to induce flicker-fusion.

In addition albinos usually have vision problems. This is well documented both in humans (e.g., Hoeft, 1991; Sowka and Gurwood, 1991) and animals (Creel, 1980; Creel et al., 1990; Garipis and Hoffmann, 2000; Hupfeld and Hoffmann, 2006). Vision was shown to play a major role in male-male interactions at adders, and spring molting seems to be the trigger for the mating combats (Andrén, 1986). After the molting male adders become exceptionally bright and vivid and their activity increases (Prestit, 1971; Andrén, 1986). Albino individuals, especially males may hardly find mates, due to their weak vision they are unable to perceive the signals of conspecifics, and also would need more time until they spot the predators. They might have success in populations with high densities, or when the operational sex-ratio is highly female biased. In such situations due to the short mating period the larger, and thus more fit, males are unable to monopolize all the females and smaller males will also achieve to mate (Madsen and Shine, 1993).

Albinos might have a higher survival chances also due to higher population densities in the north. The number of snakes per habitat unit seems to be higher in the northern parts of the species range: e.g., 3 individuals per hectare in Dischma valley, SE Alps, Switzerland (Neumeyer, 1987); 0.99 to 4.00 individuals in different populations of Western Germany (Biella et al., 1993); up to 6 individuals per hectare on the Island Stora Hästholmen, southwestern Sweden (Andrén and Nilson, 1983). Still this number is highly dependent on food availability and weather conditions (Andrén and Nilson, 1983; Forsman and Lindell, 1991; Lindell, 1997). As adders are subjected to high predation pressure by avian predators, it might be possible even for an albinistic or leucistic individual to hide from a predator due to the movement of many snakes at its approach.

The albino individual observed for *V. seoanei*, the fourth European viperin species where the color defects was observed, intimates a more widespread occurrence of the mutation, which probably is present for all European species, but for most of them is rare and has not been recorded yet.

The offset occurrence pattern of these color defects for *V. berus* specimens raises several questions which have to be answered and research on the topic has to be carried out. The albino state seems to be/was widespread in the population at Riihimäki (Table 1), and if this mutation is still preserved there, this population might serve as a test locality for the hypotheses.

CONCLUSIONS

1. Albinism and leucism probably occurs in all species of European Viperinae, but at the majority of the species is rare and has not been recorded yet.

2. Color defects are most common at *Vipera berus*, and they present an occurrence pattern shift to the Nordic Countries, probably as a result of a less intensive predation pressure and higher population densities in these populations.

3. Albino snakes, similar to albino mammals, have low survival rate, stillborns and malformed individuals occur often.

4. The color defects have negative effect on fitness, which results in a low feeding and mating success.

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