ALBINISM IN SNAKES.

By: Ed Prüst, Voorstraat 61, 3512 AK Utrecht, The Netherlands.

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INTRODUCTION

In this article, I shall treat the occurrence of albinism in snakes (the types of albinism and cross breeding patterns as far as is known in current literature) in such a manner that keepers of snakes, having perhaps little knowledge of genetics, will be able to carry out cross breeding.
With this knowledge of cross breeding, snake keepers will be able to estimate the results of their breeding programme beforehand.

TYPES OF ALBINISM

Albinism is generally defined as "the absence of normal pigmentation". It should be stated that, even in the case of normal pigmentation, considerable variations may occur in the individual colour patterns, this being amongst other factors a result of variations in environment.
In the case of the Corn snake (*Elaphe guttata guttata*) geographical colour variations are found to exist (Mitchell, 1977; Bechtel, 1980) which cannot be considered as being forms of albinism. It should also be stated that in snakes, not all albinos are white. The reason for this is that in snakes, as opposed to human beings, albinism is determined by four types of chromatophores (Wagner,

1982; Bechtel, 1978). Chromatophores are connective tissue corpuscles containing pigment granules, which, with the aid of biochemical reactions, form colour substances. As previously stated, there are four types in snakes:

1. Melanophores which produce black colour substances (pigment). These are the only chromatophores present in humans.
2. Erythrophores which produce red pigment.
3. Xanthophores which produce yellow pigment.
4. Iridophores which produce no particular pigment, but instead, very small crystals which disperse and partially reflect light particles (an example of this can be seen in the "rainbow" of the Rainbow boa (*Epicrates cenchria cenchria*).

The presence and activity of all these chromatophores is most probably determined by genetical properties. This may vary from the active presence of all four types (a normally coloured animal), to the inactivity or absence of all four types (the case in the true white albino), and all "in between variations". The following forms of albinism are therefore distinguished (Bechtel, 1978; Dyrkacz, 1981):

1. Complete albino: the absence of any skin pigment at all, not even in the eyes (these are red due to the filtering through of blood behind the eyes).
2. Partial albino with only melanophores present: no skin pigment present at all, not even in the eyes, except for black.
3. Partial albino with only erythrophores present: no skin pigment present at all, not even in the eyes, except for red.
4. Partial albino with only xanthophores present: no skin pigment present at all, not even in the eyes, except for yellow.
5. Partial albino with only iridophores present:

no skin pigment present at all, except for some copper-coloured spots.

6. Albinistic pinto (=piebaldism): small diffuse areas of normal pigmentation, and further, white colouring.
7. Leucistic albino: absence of any specific skin pigment, except in the eyes.
8. Amelanistic albino: presence of all skin pigments, except for black.
9. Anerythristic albino: presence of all skin pigments, except for red.

Although the mechanisms of all these types of albinism are most probably hereditary, the exact causes of all mutations are not yet understood (i.e. piebaldism and leucism). This also applies to the effect of the chromatophores ; the effects of melanophores and erythrophores are known, but the effects of xanthophores and iridophores are not or at least much less known. Of xanthophores, it is believed that their absence results in the occurrence of blue coloured individuals (e.g. the blue specimens of the *Chondropython viridis*).

ALBINISM IN NATURAL HABITATS

Dyrkacz (1981) mentions the following species of North American snakes as occurring in albinistic forms: *Arizona elegans, Carphophis amoenus, Coluber constrictor, Diadophis punctatus, Elaphe guttata, Elaphe obsoleta, Heterodon platyrhinos, Lampropeltis calligaster, Lampropeltis getulus, Lampropeltis triangulum, Nerodia fasciata, Natrix sipedon, Pituophis catenifer catenifer, Pituophis melanoleucus, Regina septemvittata, Sonora semi-annulata, Storeria dekayi, Thamnophis butleri, Thamnophis elegans, Thamnophis radix, Thamnophis sauritus proximus, Thamnophis sirtalis, Tropido-clonion lineatum, Virginia striatula, Crotalus atrox, Crotalus horridus, Crotalus viridis* and

Sistrurus catenatus.
Of *Elaphe guttata guttata* in its natural habitat, there are two known forms of albinism: amelanistic and anerythristic (Bechtel, 1962).

GENETICS

The hereditary properties of animals are stored in the chromosomes, of which there are two identical pairs in each living cell. Each pair however, may possess different properties (characteristics). For example: one chromosome may be carrying the genetic information "melanophores present" while the other one carries the information "melanophores absent". In a cross match this is shown as follows:
Melanophores present : *M*
Melanophores absent : *m*
As already mentioned there are two chromosomes in each pair. This is designated as:
MM when both chromosomes have "melanophores present".
mm when both chromosomes have "melanophores absent" .
Mm when both chromosomes possess different information.
In practice, this means that snakes with *Mm* and *mm* have a normal appearance (black pigment present) and that snakes with *mm* do not have a normal appearance due to the absence of the black pigment. One *M* is sufficient to give a snake a "normal" appearance; for the true absence of the melanophores, both chromosomes should have *m*.
The same applies in the case of the erythrophores (red pigment).
Erythrophores present: *E*
Erythrophores absent : *e*
This is set out in the table below:

Code	Genetic property	Colour of snake
MM	melanophores present	normal
Mm	melanophores present	normal
mm	melanophores absent	no black pigment
EE	erythrophores present	normal
Ee	erythrophores present	normal
ee	erythrophores absent	no red pigment

In practice this means that we can say: an animal without any black pigment is *mm* ; however an animal with a normal appearance may be *MM* or *Mm*.

When sex cells are produced (i.e. spermatozoa and egg cells) only one of each pair of chromosomes is stored. This means that an animal which possesses *Mm* has stored the *M* in half of its (either masculine or feminine) sex cells, and in the other half the *m*, e.g. an animal with *MM* wil will possess *M* in all its sex cells and an animal with *mm* will possess *m* in all its sex cells.
At the moment of insemination, the young obtain a set of chromosomes from both the father and the mother, which makes two sets of chromosomes again. In this manner, the young obtains, for example, an *M* from the father, and an *m* from the mother. In this case, it would result in a normally coloured juvenile (*Mm* = black pigment present), altough it would also carry the genetic property "melanophores absent".

CROSSMATCHING ARRANGEMENTS

A "crossmatching arrangement" is an aid to calculate the possible combinations of hereditary properties. If we cross a amelanistic male

of which we know that the property *mm* is present with a normally coloured female of which we assume the code *MM* to be present, then we may write this as: *MM* x *mm* .
In the crossmatching arrangement, the hereditary information of the chromosomes can be read as *MM* (top horizontal) of the female; on the left hand side of the arrangement, we read that of the male, being *mm*.

♂ \ ♀	*M*	*M*
m		
m		

In between these, the four possible combinations can be written:

♂ \ ♀	*M*	*M*
m	*Mm*	*Mm*
m	*Mm*	*Mm*

In this crossmatching arrangement, we can see that all juveniles obtain *Mm* in their hereditary properties. The result of this is that all juveniles will have a normal appearance (black pigment present). They all appear to look normal but we call them "carriers" because they carry *m* in their genetic material and can transfer this property to their next generation. These snakes are sold commercially as heterozygous for albino. Noting down all possible combinations is very useful, as can be seen when two individuals of this generation are crossed with each other. These are two animals which have a normal appearance (there is an *M* present) but which are also carriers. Crossmatching: *Mm* x *Mm* , the following four combinations can be written:

♀/♂	*M*	*m*
M	*MM*	*Mm*
m	*Mm*	*mm*

We now see that all possible combinations exist. Remember that we can only recognize an individual with *mm* as such, and not otherwise. All remaining individuals of the following generation have a normal appearance, i.e. *M* is present.
Because we do not know which chromosomes are selected for the forming of the new individuals, we assume the following: of all new individuals from such a cross-breeding, approximately 25% (one in four possibilities, ratio 1:4) will show an amelanistic pigmentation (*mm*).
Therefore, some 75% will have a normal appearance (*MM* or *Mm*), of which two thirds (2/3), i.e. 50% of the total number, will be "carrier" (*Mm*).
We may also conclude that: if we take a normally pigmented individual from this breeding, there is a 33% chance that the individual will possess *MM*. The same applies to the genetic codes *EE*, *Ee* and *ee*.

If we go one step further, we are able to observe two properties simultaneously.
Assume for example that we cross an amelanistic individual to an anerythristic individual. We can conclude beforehand that one individual will possess *mm* and the other *ee*. If we assume that both individuals possess the other property of having the double dominant form, then the cross-matching arrangement can be written as follows: *mmEE* x *MMee*. Both individuals use one chromosome from each of of their chromosome pairs. For *mmEE* this means that it can only result in sex cells with *mE*. The final combination of two parent chromosomes can, in this case, only result in *MmEe*:

♂ \ ♀	*mE*	*mE*
Me	*MmEe*	*MmEe*
Me	*MmEe*	*MmEe*

All individuals born will have a normal appearance due to the presence of *M* and *E*. However, all individuals will also be "carriers" for both properties due to the presence of *m* and *e*. As a last example, we can also observe the expected result of the crossmatching of two individuals from the previous crossmatching: *MmEe* x *MmEe*. The most simplest manner is to write down all the possible combinations which would be expected for the sex cells: *ME*, *Me*, *mE* and *me*. This applies to both individuals. Crossmatching indicates 16 possible combinations of which some are the same:

♂ \ ♀	*ME*	*Me*	*mE*	*me*
ME	*MMEE*	*MMEe*	*MmEE*	*MmEe*
Me	*MMEe*	*MMee*	*MmEe*	*Mmee*
mE	*MmEE*	*MmEe*	*mmEE*	*mmEe*
me	*MmEe*	*Mmee*	*mmEe*	*mmee*

We find 9 normal coloured combinations (*MMEE*, *MMEe*, *MmEE* and *MmEe*), three anerythristic combinations (*MMee*, *Mmee*), and three amelanistic combinations (*mmEE*, *mmEe*). Only one of the 16 combinations results in a snake which is both anerythristic and amelanistic (*mmee*).
However, it should be observed that these crossmatching arrangements only give possible indications; if one of the 16 possibilities results in *mmee* this only means that one sixteenth part (6%) of all of the new generation will possess neither red nor black pigment. This also means that approximately 19% will be amelanistic and

approximately 19% anerythristic. These percentages and ratios only apply to very large numbers of newly born individuals. Within one breeding session the proportions and ratios can vary strongly

With these examples in mind, anyone who is interested in breeding mutant colour patterns in snakes if these have a hereditary background, will be able to indicate beforehand the results of his breeding programme. However, it is possible that the number of expected colour patterns will be more than that which was expected, or, in other cases, less then was indicated.

If you are interested in additional information regarding the above article, or would like to see more crossmatching arrangements, you are advised to visit the reference section of your nearest library and refer to books and literature on genetics. The more scientific books on genetics give additional information on probability calculations in crossmatching arrangements.

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