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RAFAŁ ŁOPUCKI, IWONA MRÓZ

Department of Applied Ecology, The John Paul II Catholic University of Lublin, Konstantynów 1H, 20-708 Lublin, Poland, lopucki@kul.pl, imroz@kul.pl

Cases of colouration anomalies in small mammals of Poland, and reasons for their incidence

Przypadki anomalii ubarwienia u drobnych ssaków stwierdzone na terenie Polski oraz przyczyny ich występowania

SUMMARY

The paper presents cases of atypical colouration in small mammals from Poland described in literature and gathered through interviews with Polish theriologists. We took into account only cases of pigmentation disorders covering the whole body to be sure that they resulted from genetic trait and are not the effect of injury or frostbite. In total, 34 cases of individuals with anomalies of colouration of the whole body were found (8 insectivores and 26 rodents). They belonged to 10 species. A majority of such cases among rodents were recorded in habitats with various degree of isolation by suboptimal or unfavourable habitats. It confirmed the hypothesis of the influence of environmental conditions on the frequency of revealing the recessive alleles in populations of ground-dwelling small mammals. In the mole, however, occurrence of albinotic individuals is the result of low predator pressure, due to subterranean way of life of this species. It is suggested that changes in the genetic structure of small mammals populations, leading to revealing of recessive genetic traits like pigmentation anomalies, can serve as an indicator of environmental changes.

Key words: colouration anomalies, albinism, melanism, small mammals, habitat isolation

STRESZCZENIE

W niniejszej pracy przedstawiono przypadki nietypowego ubarwienia drobnych ssaków z terenu Polski zebrane na podstawie literatury oraz informacji pochodzących od polskich teriologów prowadzących wieloletnie badania nad tą grupą zwierząt. Pod uwagę brano przypadki anomalii dotyczących ubarwienia całego ciała (całkowity albinizm lub melanizm), by mieć pewność, że jest to cech genetyczna, a nie wynik uszkodzenia melanocytów, np. w wyniku zranienia lub odmrożenia. Stwierdzono 34 osobniki o nietypowym ubarwieniu należące do 10 gatunków: 3 gatunki ssaków owadożernych reprezentowane przez 8 osobników oraz 7 gatunków gryzoni reprezentowanych przez 26 osobników. U gryzoni większość przypadków anomalii ubarwienia została stwierdzona w siedliskach o różnym stopniu izolacji przez suboptymalne lub niesprzyjające otoczenie. Potwierdza to hipotezę o wpływie warunków środowiska na częstość ujawniania się recesywnych alleli w populacjach naziemnych gryzoni. U kretów natomiast występowanie albinotycznych osobników może być wynikiem małej presji drapieżników z powodu podziemnego trybu życia tego gatunku. Powyższe fakty sugerują, że zmiany w strukturze genetycznej populacji drobnych ssaków, prowadzące do ujawniania recesywnych cech, mogą służyć jako wskaźnik zmian środowiska.

INTRODUCTION

Mammalian colouration is most often the effect of the presence or absence of melanin pigment in the cortex and medulla of the hair, the epidermis of the skin, and an iris of the eye (Searle 1968). Synthesis of melanin takes place in special cells – melanocytes and is controlled by genes. The synthesis not always runs correctly, which leads to anomalies in the amount or type of melanin deposited in cells, and in consequence some individuals are atypically pigmented. Their colouration is conspicuously lighter, even completely white, or darker, even almost black, comparing to a coat colour typical of the species. Responsible for this are mutations of genes affecting the colour (Barsh 2001, Hoekstra 2006).

Lack or deficiency of melanin is the result of mutation in *Tyrosinase (Tyr)* gene. This mutation causes loss-of-function for tyrosinase, the enzyme which catalyses the initial step in melanin biosynthesis (oxidation of tyrosine to dopaquinone). The defective enzyme is unable to produce melanin, or produces it at a reduced rate evoking disorders in pigmentation, defined as albinism (Barsh 2001). So far, mutations in the *Tyr* gene, associated with albinism, have been found in man (Oetting et al. 2003) and other mammals like cattle, cats, rabbits, mice, rats and ferrets (Błaszczyk et al. 2007). Albinotic phenotype is characterised by: (1) the evidently lighter or even white pelage, the pink skin and red eyes defined as complete albinism, (2) lack or deficiency of pigment in the hair but unchanged colour of the eyes and the skin, called leucism, (3) loss of pigment only in some areas of the body displaying as spots or belts on the pelage or white tips of the ears or tails known as piebaldism or white spotting (partial albinism) (Sage 1963, Pucek 1964, Acevedo et al. 2009)

The occurrence of an increased amount of dark pigmentation is defined as melanism. As disorder, melanic phenotype is the result of mutation, leading to either constitutive- or hyper-activation of melanocortin-1 receptor gene, or loss-of-function of *Agouti*. This mutation causes inability of melanocytes to switch between the production of dark brow/black (eumelanin) and light yellow/red pigment (pheomelanin), resulting in domination of the former, and in consequence dark pigmentation of the coat (Kingsley et al. 2009).

In natural conditions albinism or melanism are rather rare phenomena. Firstly, due to inheritance in an autosomal recessive manner – progeny will exhibit albino or melanic traits when both parents are homozygotes or heterozygotes with altered gene affecting colour (Drożdż 1971, Brewer et al. 1993, Błaszczyk et al. 2007). Secondly, such genotypes are under the strong pressure of selection – higher mortality of albino individuals due to physiological disorders (Andrzejewski et al. 1975, Searle 1990), and higher predators pressure due to better visibility of uncommonly pigmented individuals (Simpson 1994).

In some habitat conditions, however, frequency of recessive alleles may increase. If, in the gene pool of the population, the recessive alleles conditioning albinism (or melanism) are present, the probability of their expression will be higher in isolated, inbred population than in normal outbred population (Bensch et al. 2000, Miller 2005). Also, the population bottleneck, i.e. reduction of a population to a small number and then its re-growth (Brookfield 2001) favours appearance of recessive alleles through the loss of genetic variability and increased homozygosity (Stangl et al. 1995).

Taking into account the above mentioned conditions, influencing the probability of appearance of anomalies in colouration, we can formulate a hypothesis that the group of animals most prone to the occurrence of these anomalies are small mammals, i.e. rodents and insectivores. This seems even more likely, if considered are such typical features of small mammals as: restricted abilities for long distance movements, limiting gene exchange between neighbouring populations living in fragmented habitats, outbreaks and crashes of their population numbers, close relative mating, high reproduction rate, short breeding cycle, and high progeny number per litter (Jannett 1981).

The aim of the paper was to review the cases of colouration anomalies in small mammals found within the area of Poland and analysing: (1) which species are affected by these anomalies, and (2) in what habitat conditions these cases occur most often.

MATERIAL AND METHODS

In order to collect cases of abnormal coloration in small mammals found in Poland, a review of data documented in literature since the year 1950 was conducted. The literature review was supplemented by interviews with scientists conducting studies on small mammals now and in the past in various parts of Poland.

We took into account only cases of pigmentation disorders covering the whole body to be sure that they resulted from inherited recessive trait. Cases of partial colour disorders like white spotting were omitted, because they were not always connected with genetic traits but could be the effect of melanocyte destruction due to injury, frostbite, or nutritive deficiency (Pucek 1964, Michalak 1983). Detailed information about collected cases of the whole body colour anomalies are presented in Table 1.

RESULTS AND DISCUSSION

Colouration anomalies were found in 34 individuals belonging to ten species. Eight cases were noted in three insectivorous species and 26 in seven rodent species. The majority of species were represented only by one or two atypically coloured individual. Exceptions were *Talpa europaea* and *Myodes glareolus.* There were six albinotic individuals of *T. europaea* (Photo 1), and only two of them derived from the same place (Turew, western Poland). Such high number of albino moles found in various parts of Poland confirms the hypothesis that relatively frequent appearance of albino individuals in the mole populations is the result of low predator pressure due to subterranean way of life (Yokohata 2005). Factor of habitat isolation is less important, because the mole occurs in various types of terrestrial biotopes (besides these with sandy and rocky ground), and the barriers for this species are mainly big rivers and strongly urbanised areas.

Table 1. Cases of colouration anomalies covering the whole body in small mammals from the area of Poland described in literature and according to personal information. The numbers in “Locality” column refer to the numbers in Figure 1.
Abbreviations: AMU – Adam Mickiewicz University in Poznań, CUL – the Catholic University of Lublin, N. P. – National Park

Species	Colouration anomaly	Number of individ.	Locality	Coordinates	Habitat conditions	References
1	2	3	4	5	6	7
Sorex araneus	Beige	1	[1]Kampinos N.P.	52°19’21’’ N 20°30’41’’ E	Swampy belt between two dune belts covered by forest	Fąfara and Łopucki 1999, coll. of CUL
Talpa europaea	Cream	2	[2]Turew	52°3’43’’ N 16°49’9’’ E	Village within agricultural area	Karg 2008
		1	[3]Kwiatkówek	52°15’26’’ N 20°26’48’’ E	Village within agricultural area	K. Frejlich personal inf. (Photo 1)
		1	[4]Złotogłowice	50°30’14’’ N 17°21’55’’ E	Mixed agricultural and built-up area	Museum of Opole Silesia
		1	[5]Poznań	-	-	B. Piłacińska personal inf., coll. of AMU
		1	[6]Kampinos N.P.	52°19’21’’ N 20°30’41’’ E	Eastern part of the Park neighbouring with urban area	Andrzejewski, Bednarz 1996
Erinaceus concolor	Cream	1	[7]Cracow	50°3’24’’ N 19°57’45’’ E	Urban area	Polish Television 2010
Apodemus agrarius	Light beige with brown stripe on the back	1	[8]Kampinos N.P.	52°19’21’’ N 20°30’41’’ E	Eastern part of the Park neighbouring with urban area	Andrzejewski, Bednarz 1996
Apodemus flavicollis	Light beige with red eyes	1	[9]Miłachowo reserve	53°32’16’’ N 17°12’31’’ E	Forest and shrubby area (3.7 ha) in agricultural terrains	Ciechanowski 2002
Microtus arvalis	Ruby (flavescent)	1	[10]Domasław near Wrocław	51°0’42’’ N 16°57’23’’ E	Agricultural area	Humiński 1963
	White upper part of guard hair	1	[11]Płochocin	52°12’00’’ N 20°43’16’’ E	Mix of agricultural and built-up area	R. Andrzejewski personal inf. coll. of CUL
Microtus oeconomus	Cream	1	[12]Kampinos N.P.	52°19’21’’ N 20°30’41’’ E	Swampy belt between two dune belts covered by forest	M. Włodarz personal inf.

1	2	3	4	5	6	7
Myodes glareolus	Cream with red eyes	1	[13]Kampinos N.P.	52°19’21’’ N 20°30’41’’ E	Narrow belt of alder forest at the edge of a village	Andrzejewski, Bednarz 1996 (Photo 2)
	Black	16	[14]Niepołomice forest	50°2’59’’ N 20°19’59’’ E	Isolated forest complex (11000 ha)	Bobek and Bartke 1967, Drożdż 1971
Ondatra zibethica	Albino specimen	1	[15]Poznań	52°22’07’’ N 16°55’9’’ E	Urban area	Mizera 1996
Pitymys subter-raneus	Black with grey hair	2	[16]Warsaw	52°12’56’’ N 21°1’60’’ E	Urban area – Łazienki Park	R. Andrzejewski personal inf. coll. of CUL

Photo 1. Albinotic specimen of *Talpa europaea* found in Kwiatkówek (central Poland, 52°15’26’’ N 20°26’48’’ E). Author: Klaudiusz Frejlich

In *M. glareolus* as many as 16 melanic individuals were recorded, all in the same place – the Niepołomice Forest. It was the result of the presence in the bank vole population of many heterozygotes with the recessive allele expressed in homozygotes as extremely non-agouti (black) phenotype (Bobek and Bartke 1967, Drożdż 1971). Retention of this recessive allele in population and frequently appearing homozygotes could be the effect of the long-lasting isolation of the Niepołomice Forest. It is the natural forest complex (11, 000 ha) situated in southern Poland, between the forks of the Vistula and Raba Rivers, isolated since c.a. the 14th century from other forests complexes by Cracow urban agglomeration, small villages and agricultural terrains (Rokosz 1984). Melanistic bank voles from the Niepołomice Forest were kept and bred succesfully in captivity. Some of them were also introduced to other populations of this species. In 1971, 25 individuals of melanistic bank voles were introduced into the population of Crabapple Island at Bełdany Lake (53°42'11"N, 21°34'22"E). Black individuals were recorded in this population for four years. The frequency of capturing of the black bank voles was 2–12 per 50–1000 typically colourized individuals (R. Andrzejewski – personal inf.).

On the other hand, the highest number cases of atypically colourized small mammals was found in central Poland, in the Kampinos National Park and its vicinity. There were recorded nine individuals of seven species (Table 1). One of the species – the beige bank vole (male) (Photo 2), have been kept in captivity, and crossed with the female having typically coloured coat originating from the Kampinos N.P. Progeny, 6 pups, had the same beige colour. This may mean that randomly selected individual with typical colour of the coat was a heterozygote, and carried the gene of the light colouration (R. Andrzejewski personal inf.).

Photo 2. Beige specimen of *Myodes glareolus* found in the Kampinos National Park (central Poland 52°19'21" N 20°30'41" E). Author: Piotr Pukos

Besides small mammals, also wild boars *Sus scrofa* with white-cream coat with black spots have been met here (Andrzejewski et al. 1975). The frequency of occurrence of this mutation in young wild boars amounted to 1 for every 38.6 animals with normal coat colour (Andrzejewski 1974).

Major number of colouration anomalies in this locality of central Poland, similar to the Niepołomice Forest, may result from habitats isolation. The Kampinos N.P. and its vicinity are surrounded by dense infrastructure of Warsaw and other smaller cities, as well as by the rivers, the big Vistula and the smaller Bzura. Additionally, within the Park occurs natural and anthropogenic habitat fragmentation. The belts of high dunes covered by dry, pine forests divide belts of swampy depressions with non-forest communities. The swampy belts lost their continuity due to natural succession and reforestation (Mróz et al. 2009). An isolation of interior and exterior habitats certainly creates obstacles for gene flow. Appearance of abnormal colouration in the population of European pine vole inhabiting the Łazienki Park in the centre of Warsaw (R. Andrzejewski personal inf.), was certainly the effect of isolation.

The remaining cases of colouration anomalies recorded in other parts of Poland were also found in habitats isolated by suboptimal or even unfavourable habitats. Yellow necked mouse was noted in the Miłachowo reserve, a small shrubby-forest locality surrounded by an agricultural area (Ciechanowski 2002). Muskrat and hedgehog derived from the big cities (Poznań and Cracow) with strongly urbanised neighbourhood (Mizera 1996, Polish Television 2010).

All mentioned above cases of colouration anomalies were found in the central and western Poland (Fig. 1), whereas in the eastern and south-eastern part of Poland there were no reports neither in literature (Haitlinger and Szyszka 1977, Buchalczyk and Markowski 1979, Górecki et al. 2000, Kubik and Gawron 2001, Górecki and Jamrozy 2003, Dziedzic et al. 2006, Falkowski 2006, Łopucki and Mróz in press) nor by scientists who have conducted studies on small mammals in these regions, i.e. the Białowieża Forest, mountainous and submountainous regions (Leszek Rychlik, Andrzej Górecki, Ryszard Haitlinger – personal inf.). It is well known that eastern parts of Poland are less transformed by man and have a greater degree of naturalness than central and western regions (Grabińska 2007, Roo-Zielińska et al. 2007, Biernacka 2009), e.g. habitats are less isolated and forest complexes maintained connectivity even for over 100-km distance.

Summarizing, colouration anomalies of the whole body occur in various species of small mammals representing a variety of life style (underground, ground-dwelling, semi-arboreal or semi-aquatic), and inhabiting various types of biotopes (forests and meadows of different humidity, agricultural and urban areas, waters). Lack of reports on atypically colourized individuals in other species of Micromammalia does not mean that such disorders are not present in those

Fig. 1. The map of Poland with main rivers and localities of colouration anomalies found in small mammals. The numbers in brackets refer to the numbers given in the "Locality" column of Table 1

populations. There are examples of e.g. partial albinism, being probably the genetic trait, in *Sorex minutus* (Pucek 1964), *Neomys fodiens* (Rachowiak 1990), and *Microtus agrestis* (Haitlinger, Humiński 1963).

The cases of colouration anomalies found in Poland support the hypothesis that the frequency of occurrence in a population atypically colourized individuals is largely affected by environmental conditions. Stangl et al. (1995) suggest that genetically inherited recessive traits such as colouration anomalies can indicate a bottleneck and inbreeding occurring in a population actually or in the past. These events are often the effect of destructive alteration of habitats. Thus, changes in the genetic structure of small mammals populations, displayed as albinism or melanism may be indicators of environmental changes, supplementing other indicators, used for this purpose, based on geobotanical, soil or landscape characteristics.

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