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Interallelic interaction between the autosomal Blond and the sex-linked *Nigrocaudatus* gene in the guppy (*Poecilia reticulata*)

^{1,2,3,4} I. Valentin Petrescu-Mag, ^{1,2} L. Radu Lozinsky, ¹ Radu Hărșan,
¹ László Csép and ^{1,3} Anca M. Boaru

¹ University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Animal Husbandry, Department of Aquaculture, Cluj-Napoca, Romania. ² Bioflux SRL – Research Organisation, Cluj-Napoca, Romania. ³ 3M Antreprenor General Construcții SRL, Cluj-Napoca, Romania. ⁴ University of Agricultural Sciences and Veterinary Medicine „Ion Ionescu de la Brad”, Iași, Faculty of Animal Sciences, Postdoctoral School in Agriculture and Veterinary Medicine, supported by POSDRU Programme, European Union.
Corresponding author: I. V. Petrescu-Mag, zoobiomag2004@yahoo.com

Abstract. The paper presents results on guppy genetics, from the project CEEEX 140/2006. The sex-linked *Nigrocaudatus* gene is dominant to its wild alleles and epistatic to all the non-allelomorphic genes affecting posterior body color. Autosomal Blond gene is recessive to its wild allele and is expressed in homozygote form only. In this form, it partially suppresses both the *Nigrocaudatus* and other melanistic genes due to a low level of melanin synthesis. Other body and fin color traits than melanistic ones (blue, green, red-orange, yellow etc) are expressed at normal intensity in blond varieties.

Key Words: epistasis, hypostatic, *Poecilia*, Blond, *Nigrocaudatus*.

Note. The present manuscript was accepted for publication in the current form in Acta Ichthyologica Romanica in 2007 but not published and delayed for years and therefore withdrawn by the authors. The manuscript was distributed as final form and several opinions or critical reviews were published by other authors, the most important comments being those of Shaddock (2008). Although later the manuscript needed revision on a large extent, we preferred to keep it and publish in the current form because it is necessary and complementary to the observation published by Shaddock (2008). The paper of Shaddock and its point of view is brighter and easier to understand when it is read together with our paper in the original form. This paper was cited in literature as “Petrescu-Mag I. V., Lozinsky R. L., Hărșan R., Csép L., Boaru A. M., 2007 Interallelic interaction between the autosomal Blond and the sex-linked *Nigrocaudatus* gene in the guppy (*Poecilia reticulata*). AIR 2(1)”.

Introduction. One of the most popular, and colorful species of ornamental fish, having numerous standardized varieties of shape and color, is the guppyfish or the millionfish. These fish are required and produced for the aquarium market in giant numbers. The males have many conspicuous color patterns termed by Winge (1922) morphs. These morphs are often X-linked, Y-linked, or both X and Y-linked (Lindholm & Breden 2002). A few color traits show to be autosomal (Winge 1927; Haskins & Haskins 1948; Dzwillo 1959; Schröder 1969; Horn 1972; Phang et al 1999). Blond (bb) is such an autosomal trait (Goodrich et al 1944; Phang & Doyle 1988). The paper debates the interallelic interaction between this gene and *Nigrocaudatus* II gene.

Material and Method. In the CEEEX 140/2006 research project we made a few crossings between Red Blond variety and Half-Black Black variety of guppy and we used

Nigrocaudatus as marker gene of the X chromosome for selection of a cryoresistant guppy strain. The result was a patent (Petrescu-Mag et al 2007, data not shown here) and also some new information regarding epistasis of blond to other epistatic genes.

Ten Red Blond males ($ni\ ni\ b\ b$) were crossed with twenty Half-Black females ($Ni\ Ni\ B\ B$) and 100% Half-Black progeny resulted in F1 generation ($Ni\ ni\ B\ b$; Fig. 1). Twenty from the F1 females were backcrossed with the previous ten Red Blond males ($ni\ ni\ b\ b$) and the registered numeric data were included in a Table (Table 1).

Table 1

Resulted genotypes, phenotypes, number of individuals, and percentages in the case of Half-Black X Red Blond backcross

Gametes	$Ni\ B$ and $ni\ b$	$Ni\ b$ and $ni\ b$	$ni\ B$ and $ni\ b$	$ni\ b$ and $ni\ b$
Genotypes FB	$Ni\ ni\ B\ b$	$Ni\ ni\ b\ b$	$ni\ ni\ B\ b$	$ni\ ni\ b\ b$
Phenotypes FB	Half-Black	Half-Black blond	Wild type	Blond
Number	43	47	39	41
Observed percentage	25.29%	27.65%	22.94%	24.12%
Expected percentage	25.00%	25.00%	25.00%	25.00%

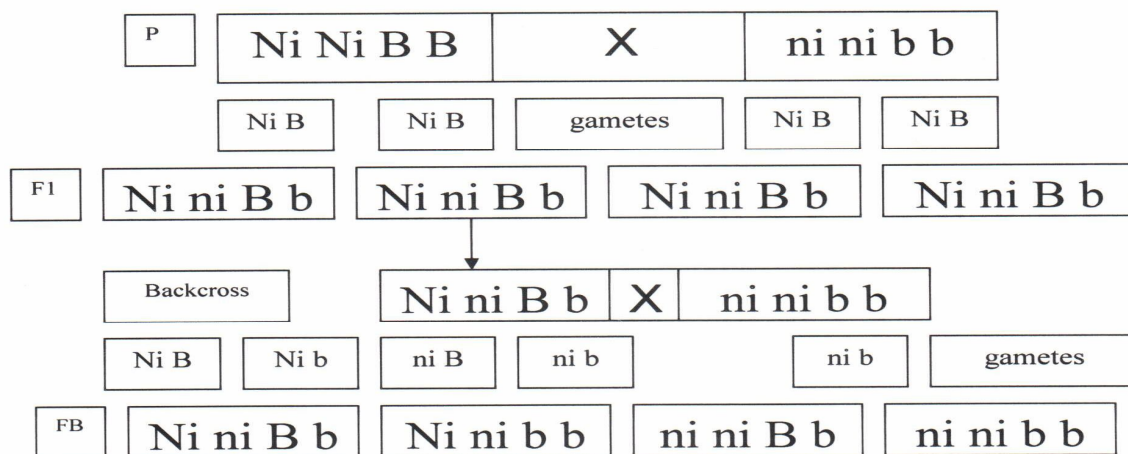


Figure 1. The genotypes resulted in F1 and FB progeny after Half-Black X Red Blond cross.

Fish were kept in aquariums at $25 \pm 1^\circ C$ under a 14/10 h light/dark cycle. They were fed with a commercial diet Tetramin® bioactive formula (Tetra GmbH, Germany), with 48% protein, three times a day *ad libitum*. Water quality parameters (O_2 , pH, ammonia, nitrite and nitrate) were monitored every 10 days during the experiment. A total number of 10 aquaria of different sizes (5 to 300 L) and 10 net cages of 20 cm x 15 cm x 15 cm were used for fish keeping and reproduction. Water was well aerated and heated using a compressor and thermostatically controlled heaters (Aquael, Poland). All water tanks were cleaned daily by siphoning the excreta and uneaten food. Color patterns were directly observed in male progeny only, at the full sexual maturity, at three months age.

Results and Discussion. From the total of 170 males resulted in FB, $\frac{1}{4}$ were Half-Black original phenotype ($Ni\ ni\ B\ b$), $\frac{1}{4}$ were Half-Black blond ($Ni\ ni\ b\ b$), $\frac{1}{4}$ were wild type ($ni\ ni\ B\ b$), and $\frac{1}{4}$ were wild type blond ($ni\ ni\ b\ b$). Chi square test indicated a 1:1:1:1 segregation, according to Mendelian laws.

Wild type guppy (BB or Bb) is characterized by conspicuous combinations of black, white, red-orange, yellow, green, iridescent, and other spots, speckles, and lines (Houde 1997). Wild phenotypes express in males only, and not at all in females.

Half-Black phenotype is characterized by posterior half of the body black. Any other trait is delayed in this body region because of dominant *Nigrocaudatus* gene (Petrescu-Mag 2007a). *Nigrocaudatus* can be type I (Nybelin 1947) or type II (Dzwillo 1959; Nayudu 1979). The first one is a less frequent form and it is X-linked, the second one can be both X or Y-linked.

Blond phenotype is determined by an autosomal recessive gene (bb) which gives rise to a pale yellow pigmentation (Goodrich et al 1944; Phang & Doyle 1988), due to a low level of melanin synthesis (Petrescu-Mag 2007b). Most melanistic genes are expressed at a reduced intensity because of autosomal blond gene in homozygote form. Other body and fin color traits than melanistic ones are expressed at normal intensity (blue, green, red-orange, yellow etc) in blond varieties.

Half-Black blond phenotype is characterized by a weak expression of *Nigrocaudatus* gene, dominant and epistatic to all the wild patterns, but hypostatic to blond in homozygote form (bb). In the presence of its wild allele (B) the blond trait is not expressed at all, but in homozygote form it is epistatic to all the melanistic genes known in the guppy, including *Nigrocaudatus* gene.

Generally, epistasis is dominance of one gene over a nonallelic gene. The gene suppressed or partly suppressed is said to be hypostatic. Here, the term epistasis is used to describe all types of interallelic action whereby manifestation at any locus is affected.

Conclusions. The sex-linked *Nigrocaudatus* gene is dominant to its wild alleles and epistatic to all the not allelomorphic genes affecting posterior body color. Autosomal blond gene is recessive to its wild allele and is expressed in homozygote form only. In this form, it partially suppresses both the *Nigrocaudatus* and other melanistic genes due to a low level of melanin synthesis.

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Authors (multiple addresses are given for same authors due to co-affiliation):

Ioan Valentin Petrescu-Mag, University of Agricultural Sciences and Veterinary Medicine, 3-5 Calea Mănăştur Street, Cluj-Napoca 400372, Cluj County, Romania; e-mail: zoobiomag2004@yahoo.com

Ioan Valentin Petrescu-Mag, Bioflux SRL – Research Organisation, 54 Ceahlău Street, Cluj-Napoca 400488, Cluj County, Romania.

Ioan Valentin Petrescu-Mag, University of Agricultural Sciences and Veterinary Medicine „Ion Ionescu de la Brad”, Iași, Faculty of Animal Sciences (Postdoctoral School in Agriculture and Veterinary Medicine, cofinanced by POSDRU Programme, European Union), 3 Mihail Sadoveanu Street, Iași 700490, Romania.

Ioan Valentin Petrescu-Mag, 3M Antreprenor General Construcții SRL, Piața 1 Mai, nr 3, Cluj-Napoca 400058, Cluj County, Romania.

Radu Laurențiu Lozinsky, University of Agricultural Sciences and Veterinary Medicine, Faculty of Animal Husbandry, Department of Aquaculture, 3-5 Calea Mănăştur, Cluj-Napoca 400372, Cluj County, Romania, radu_lozinsky71@yahoo.com

Radu Hărșan, University of of Agricultural Sciences and Veterinary Medicine, Faculty of Animal Husbandry, Department of Aquaculture, 3-5 Calea Mănăştur, Cluj-Napoca 400372, Cluj County, Romania, e-mail: harsan_radu@yahoo.com

Csép László, University of Agricultural Sciences and Veterinary Medicine, Faculty of Animal Husbandry, Department of Aquaculture, 3-5 Calea Mănăştur, Cluj-Napoca 400372, Cluj County, Romania, e-mail: csep_laszlo@yahoo.com

Anca Mihaela Boaru, of Agricultural Sciences and Veterinary Medicine, Faculty of Animal Husbandry, Department of Aquaculture, 3-5 Calea Mănăştur, Cluj-Napoca 400372, Cluj County, Romania, e-mail: anca_boaru@yahoo.com

Anca Mihaela Boaru, 3M Antreprenor General Construcții SRL, Piața 1 Mai, nr 3, Cluj-Napoca, Cluj County, Cod poștal 400058, Romania.

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