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Short communication

A remarkable teratological case in *Carabus violaceus* L. (Coleoptera: Carabidae) from Poland

AXEL SCHWERK[1]
DANIEL KLICH[2]
ELŻBIETA WÓJTOWICZ[3]

[1] Institute of Environmental Engineering, Department of Landscape Art, Warsaw University of Life Sciences – SGGW

[2] Institute of Animal Sciences, Department of Animal Genetics and Conservation, Warsaw University of Life Sciences – SGGW

[3] Kobiór Forest District, State Forests

Correspondence:
Axel Schwerk
E-mail: axel_schwerk@sggw.edu.pl

Nonstandard abbreviations
The manuscript does not contain any nonstandard abbreviations

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Abstract

Background and purpose: *Teratological cases in insects can be of different characteristic, quite often they are bifurcations, for example of antennal segments or parts of the legs. The aim of this paper is to report a case of leg duplication in* Carabus violaceus *L.*

Materials and methods: *In the context of an interdisciplinary monitoring in the frame of a conservation project on the European bison (*Bison bonasus *(L.)) in Poland the carabid fauna (Carabidae) on areas grazed by this species was studied using pitfall traps in the Pszczyna forest, located in Silesia Province, to the south of the town Tychy. The traps were located inside a mixed fresh coniferous forest, with domination of Scots pine (*Pinus sylvestris *L.).*

Results: *Among the carabids gathered a teratological female specimen of the species* Carabus violaceus *L. with multiple anatomical duplications on the right front leg was collected.*

Conclusions: *The multiple incident of bifurcation may suggest a genetic base of the teratology. In the case of increased rates teratological cases may have potential as bioindicator.*

INTRODUCTION

Teratology deals with causes, mechanisms, and patterns of abnormal physiological development. It arose as modern science in the 1930s with the publication of malformations on pigs *(1)*. Teratological cases in insects are a well-known phenomenon. Clark & Neto *(2)* provided an overview showing that virtual all body parts can be affected.

Teratological cases can be of different characteristic. Often they are multiplications of body parts. Bifurcations have been described regularly, for example of antennal segments *(e.g. 3, 4, 5, 6)*, parts of the legs *(e.g. 7, 5, 6)* or the thoracic scutum *(8)*. The first author of this note had observed antennal bifurcations in *Carabus hortensis* L. and *Carabus problematicus* Herbst, leg bifurcation in *Nebria brevicollis* (Fabricius), and duplication of ungues in *Pterostichus niger* (Schaller) (unpublished data). Trifurcations have been also described, for example in the middle leg of *Phyllophaga glaberrima* (Blanchard) *(9)* or in the antenna of *Eucymatodera parva* Schenkling *(10)*. Other multiplications of body parts concern, for example, supernumerary ocelli *(11)*.

Teratological cases different from multiplications have been reported, too. For example, Clark & Neto *(2)* described a teratological case where body parts were fusing together. The external surface of the head of an individual of the chrysomelid beetle *Pseudoluperus longulus* (LeConte) consisted almost entirely of a single holoptic eye. Location of antennae and shape of the interantennal carina were unusual, too. A teratology in the click beetle *Hemicrepidius niger* (L.) showed atrophy, underdevelopment and distortions or displacement of some parts of the left body side *(12)*. Jones *(13)* described stunted right middle legs in individuals of *Galerucella sagittariae* (Gyllenhal).

According to Clark and Neto *(2)* some teratological cases in insects are coded in the DNA, whereas others are often triggered by environmental factors. Genetical causes can be autosomal genetic diseases or have cytogenetical reasons. Environmental causes can be, for example, maternal infections or exposure to hazards or radiation *(1)*. Such reproductive toxicants may affect directly the genome or led to teratological cases because of causing disturbances such as in the enzyme system or the electrolyte balance *(1)*. In insects malformations in the imago may also occur because of mechanical damage during the pupa stage *(12)*. According to Cockayne *(7)* injury of embryonic appendages is even the usual cause of reduplications.

In this note a leg teratology in the carabid beetle species *Carabus violaceus* L. is reported. This case stands out with the completeness and high grade of development of the duplicated body parts.

METHODS

In the context of interdisciplinary monitoring in the context of a conservation project on the European bison (*Bison bonasus* (L.)) in Poland also the carabid fauna (Carabidae) of areas grazed by this species was studied using pitfall traps *(14)*. The study was conducted in the Pszczyna forest, located in Silesia Province, to the south of the town of Tychy. The total area of this forest complex comprises 40 thousand hectares, where forested area reaches 22 thousand hectares (56 % of the total area). The Pszczyna forest is a part of the Forest Protective Belt of the Upper-Silesian Industrial Region and plays an important role in local short-term tourism *(15)*. The trapping site was located in the south-eastern part of the forest (50° 1'57.68"N, 19° 1'34.30"E), about 100 m from the European bison reserve, where 42 bison are kept in captivity *(16)*. Pitfall traps *(17)* were located within a mixed fresh coniferous forest, with domination of 120 years old Scots pine (*Pinus sylvestris* L.), with mixture of 120 years old oak (*Quercus* spec.), 60 years old Norway spruce (*Picea abies* (L.)) and 60 years old silver birch (*Betula pendula* Roth) *(18)*.

RESULTS

Among the carabids trapped during the period from 16.07.-01.08.2018 a teratological female specimen of the species *Carabus violaceus* L. was collected. The specimen shows anatomical duplications on the right front leg (Fig. 1). The femur of the leg is thickened. From this femur originate two tibiae, of which the more anterior one is thickened and somewhat shortened compared to the posterior one. From the thickened tibia originate two tarsi, which are fully developed. Besides the abnormalities described here, no further duplications were observed in this specimen.

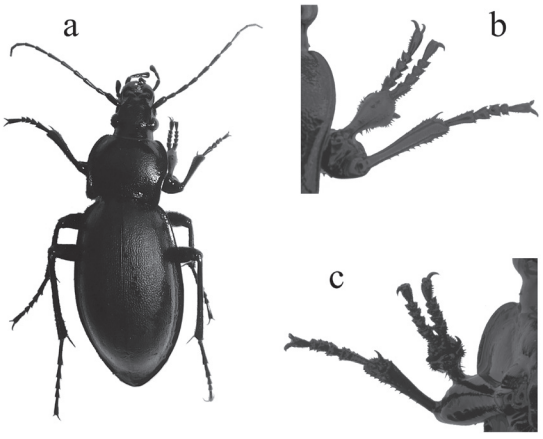

Fig. 1. *Teratological specimen of* Carabus violaceus *L.: a) Dorsal view, b) detail – dorsal view, c) detail – ventral view.*

DISCUSSION

Bifurcations of legs, as observed in the specimen described here, have been described by Cockayne *(7)* and Háva *(6)*. Háva *(6)* described a case of repeated bifurcations (*i.e.* one of the double body parts is again bifurcated) of the tarsomeres on the posterior right leg of a beetle from Indonesia and Cockayne *(7)* describes a repeated bifurcation on a leg of *Prionus coriaceus* L.

According to Cockayne *(7)* reduplications are usually caused by injury of embryonic appendages and follow Bateson's Law, *i.e.* when reduplication takes place there is the original appendage and two extra ones. However, partial fusion of the respective body parts is common and may partly hide multiple bifurcations. In the presented example, the occurrence of multiple bifurcation may also suggest a genetic base or an environmentally induced mutation as cause of the teratology. Genetic triggers of bifurcations have been shown, for example Theisen *et al. (19)* reported a thick veins (*tkv*) gene clone that resulted in a small bifurcation in the Drosophila leg. Huruk *(8)* assumes genetic factors rather than mechanical damage to

be responsible for a thoracic scutum duplication in the carabid species *Pterostichus melanarius* (Illiger), because of the complete duplication of the scutum, structural regularity of both parts, and the finding of preserved setae at parts borders of both parts of the scutum.

As suggested by Ferrer *et al. (3)*, in the case of increased rates teratological cases may have potential as bioindicator. For example, Akimoto *(20)* reported that the proportions of teratological cases and mortality of first instars of gall-forming aphids, derived from the first sexual reproduction after the Fukushima accident, were significantly higher in the Fukushima population than in control populations from noncontaminated areas. From second-generation larvae only 0.37% had abnormalities, suggesting that abnormalities found in the first generation were not inherited by the next generation. Hesse-Honegger and Wallimann *(21)* reported increased percentage values of teratological cases in true bugs (Heteroptera) in the vicinity of nuclear-power installations in Switzerland far above values expected for natural populations according to reference biotopes. They assume the release of anthropogenic radionuclides that have entered the food chain as the most rational explanation of the results. More studies comparing rates of teratological cases in populations from contaminated habitats with undisturbed ones will strengthen the indicatory potential of teratological cases in insects.

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