

Blue-colour variants of the crayfish *Austropotamobius pallipes* in 2 rivers of the Abruzzo region, Italy

Riccardo Caprioli*, Paola Garozzo, Carla Giansante & Nicola Ferri

Department of Freshwater Biology, Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale',
Campo Boario, 64100 Teramo, Italy

* Corresponding author at: Department of Freshwater Biology, Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale',
Campo Boario, 64100 Teramo, Italy.
Tel.: +39 0861 332764, e-mail: r.caprioli@izs.it.

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Freshwater crayfish,
White clawed crayfish.

Summary

Blue-colour variants have been reported in American and Australian freshwater crayfish species. We report here the observation of 2 *Austropotamobius pallipes* individuals with a blue-colour carapace in 2 rivers of the Aterno-Pescara river basin, located in the Abruzzo region, Central Italy.

Varianti di colore blu dei gamberi *Austropotamobius pallipes* in 2 fiumi della regione Abruzzo, Italia

Parole chiave

Abruzzo,
Austropotamobius pallipes,
Colore blu,
Gamberi d'acqua dolce,
Gambero di fiume dai
piedi bianchi.

Riassunto

Varianti di colore blu di specie americane e australiane di gamberi d'acqua dolce sono state riportate in passato. Questo studio descrive 2 individui della specie *Austropotamobius pallipes* con un carapace di colore blu ritrovati in 2 corsi d'acqua del bacino del fiume Aterno-Pescara, in Abruzzo, nell'Italia centrale.

Crayfish belong to the *Decapoda taxon* and are the largest mobile freshwater invertebrates (Holdich, 2002). They occur naturally in a wide range of freshwater ecosystems where they may play both the role of consumers and prey, and act as key energy transformers in aquatic food webs (Momot *et al.* 1978).

Many species are present in North America, where some of them are the objects of intensive aquaculture activities (Huner, 1994). There are only 5 native species in Europe: the noble crayfish (*Astacus astacus*) of North-West Europe, the white clawed crayfish (*Austropotamobius pallipes*) of South-West and West Europe, the related *Austropotamobius torrentium*, and the Turkish crayfish (*Astacus leptodactylus*). The populations of the European species, in particular *A. astacus* and *A. pallipes*, have drastically declined in recent years because of human factors, including pollution, damage to the

habitats, and the introduction of North American crayfish species (Holdich *et al.* 2009, Aquiloni *et al.* 2010). Besides acting as competitors of the native species, the American crayfish are often carriers of the 'crayfish plague', an infectious disease caused by the oomycete *Aphanomyces astaci* that, in some European countries, has eliminated entire populations of native crayfish (Edgerton *et al.* 2004, OIE 2009). In Europe, *A. astacus* and *A. pallipes* are involved in conservation and management programs. These 2 species are infact listed as endangered in the IUCN Red List of Threatened Species (Füreder *et al.* 2010) and included in Annexes II and V of the EC Habitats Directive¹.

¹ European Commission. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. *Off J*, **L 206**, 22/07/1992.

In Italy, *A. pallipes* represents the most common native species (Scalici et al. 2009, Aquiloni et al., 2010). It inhabits cold and well-oxygenated waters (Souty-Grosset et al. 2006) and shows the characteristics of K-selected species: high longevity, low fertility, low juvenile survival rates, slow growth, and late maturity (Scalici et al. 2008). *Austopotamobius pallipes* adults may reach a total length of over 12 cm from the tip of the rostrum to the telson. Their carapace colour is highly variable and may depend on the developmental stage, the environment as background coloration, and the diet; but variants may also depend on genetic factors (Hedgecock et al. 1982). *Austopotamobius pallipes* adults are mainly olive-brown or brown, but black, whitish-grey, or beige variant may occur, while blue variants have been occasionally recorded (Souty-Grosset et al. 2006). We report here the observation of 2 *A. pallipes* individuals with a blue-colour carapace found in 2 watercourses of the Aterno-Pescara river basin, located in the Abruzzo region, Central Italy.

The 2 animals were observed during field monitoring activities of the *A. pallipes* populations in the river basins of the Abruzzo region, conducted within the framework of a regional conservation and management program of the natural crayfish populations (Caprioli et al. 2013b). Both crayfish were adult females and were found during sampling visit carried out during the night, by using flashlights. The first individual was observed in the Samocito brook on August 4, 2010. The second individual was found in the Tirino river on the September 1, 2013. Figure 1 and Table I show respectively the map of the Aterno-Pescara river basin and the location and characteristics of the sites where the blue color variants of *A. pallipes* were observed. Both animals showed a dark blue-colour (Figure 2), but otherwise had the typical morphological characteristics of *A. pallipes*. They were maintained in captivity for 24 hours and released in the capture place after being accurately classified, sexed, and photographed.

The earliest record of blue-colour variants in freshwater crayfish was published by Lereboullet (Lereboullet 1851). Later on, blue-colour variants have been distinguished in light and dark blue phenotypes and have been reported for several North American crayfish species, including *Cambarus carolinus*, *Pacifasticus* spp., *Procambarus clarkii*, *Procambarus acutus acutus*, *Orconectes immunis*, and *Orconectes virilis* (reviewed by Momot & Gall, 1971). A blue-colour variant has also been reported for the Australian crayfish *Cherax destructor* (Walker et al. 2000). For European crayfish, to the best of our knowledge, specific reports of blue variants have never been published. Although blue specimens have been mentioned in the general morphological description of the species (Holdich 2002, Souty-Grosset et al. 2006).

Table I. Geographic coordinates and features of the 2 river sites where the *Austopotamobius pallipes* blue color variants were observed.

Brook characteristics	Samocito Brook	Tirino Brook
Geographic coordinates	42,47171° N 13,23058° E	43° 16,635 N 13° 46,321 E
Altitude (m)	844	342
Mean brook width (m)	1	3.5
Mean water depth (m)	0.2	0.9
Stream flow velocity (0-5)	1	3
Shelters availability (0-5)	1	4
Silt (% sup)	90	30
Sand (% sup)	0	20
Pebbles (% sup)	0	5
Cobbles (% sup)	0	40
Boulders (% sup)	10	5
Bedrock (% sup)	0	0
Temperature at sampling (°C)	16.2	11.7
pH	7.57	7.28
Conductivity μ S/cm	545	617
O ₂ mg/l	9.71	8.42

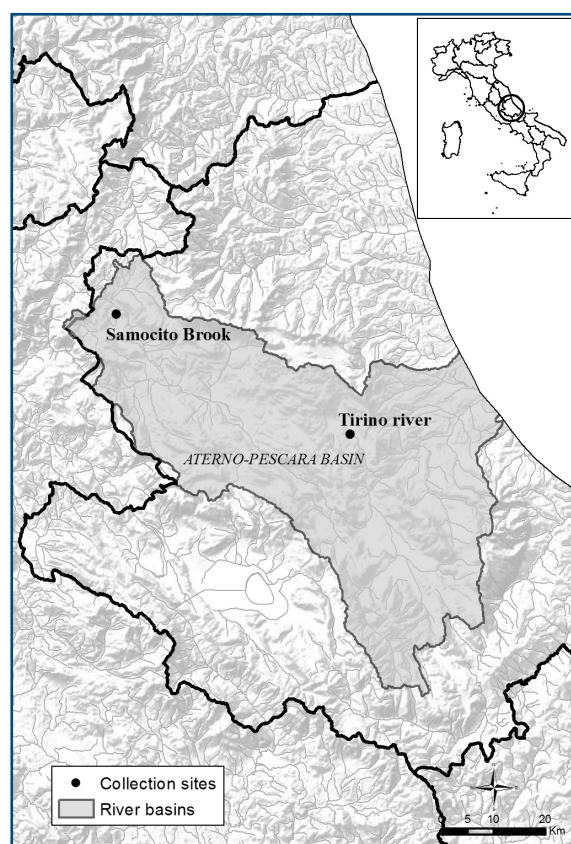


Figure 1. Map of the Aterno-Pescara river basin (Abruzzo region, Italy), with the location of the sampling sites on the Samocito and Tirino rivers, where the blue color variants of *A. pallipes* were observed.



Figure 2. Photographs of the blue crayfish found in the Samocito Brook (Abruzzo region, Italy).

In crayfish, the colour of the carapace is due to the presence of carotenoid pigment deposits on the first layer of the endocuticle, which forms the exoskeleton (Goodwin 1960). The pigment mainly involved is the astaxanthin (Meyers and Bligh 1981), but other carotenoids have been identified in *A. astacus* (Czeczuga and Czerpa 1969). In normally coloured crayfish, carotenoid molecules combine with proteins to form different carotenoproteins that mixed together give the characteristic olive-brown coloration. If the pigment-protein complexes are not properly formed, blue-colour variants may occur (Momot and Gall 1971). Black and Huner (Black and Huner 1980) and Nakatani (Nakatani 1999) demonstrated that the dark blue phenotype of *Procambarus clarkii* is the result of an inherited, autosomal recessive trait, resulting from a mutation in the gene responsible for pigment formation. The mutation was shown to be controlled by Mendelian laws and is also apparently lethal for males in early development stages, since all the dark blue *P. clarkii* observed in those studies were females. It is interesting to note that also the 2 blue *A. pallipes* individuals observed in this study were females.

The frequency of the blue-colour variants among the *A. pallipes* populations of the Abruzzo rivers appears

to be low, taking into account that the 2 individuals herein described were observed within a 5-years monitoring period (Caprioli *et al.* 2013b). During this period of time 1000 individuals were recorded and epidemic outbreaks of crayfish plague involving many animals were also detected (Cammà *et al.* 2010, Caprioli *et al.*, 2013a). Interviews conducted with tour-operators who manage canoeing centers operating in the same rivers described in this study revealed that the observations of blue-colour crayfish were not unprecedented, albeit rare. Data on the frequency of blue-colour variants in *A. pallipes* or other crayfish species are scanty. However, in a study conducted on the *Orconectis virilis* populations of 2 lakes in Michigan, US, the percentage of crayfish that were blue in colour was reported as very small (Momot & Gall 1971), and blue phenotypes were reported to occur at low frequency also in natural or cultured populations of *Procambarus acutus* (Black 1975) and *Cherax destructor* (Walker *et al.* 2000).

In conclusion, the blue variants of *A. pallipes* recorded in the Abruzzo rivers represent a natural phenomenon, which, as in other crayfish species (Momot & Gall, 1971; Black, 1975; Walker *et al.* 2000), is likely to occur at very low rates and can be due to an inherited autosomal recessive trait.

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