Rapid Communication

First report of golden crayfish *Faxonius luteus* (Creaser, 1933) in South Dakota

Gene Galinat[1,*], Mael Glon[2] and Brian Dickerson[3]

[1]*South Dakota Department of Game, Fish and Parks, Rapid City, South Dakota, USA*
[2]*The Ohio State University Museum of Biological Diversity, Columbus, Ohio, USA*
[3]*U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station, Rapid City, SD, 57702, USA*

Author e-mails: *gene.galinat@state.sd.us* (GG), *glon.1@osu.edu* (MG), *brian.e.dickerson@usda.gov* (BD)

**Corresponding author*

Citation: Galinat G, Glon M, Dickerson B (2021) First report of golden crayfish *Faxonius luteus* (Creaser, 1933) in South Dakota. *BioInvasions Records* 10(1): 149–157, https://doi.org/10.3391/bir.2021.10.1.16

Received: 7 February 2020
Accepted: 20 August 2020
Published: 1 December 2020

Handling editor: David Hudson
Thematic editor: Karolina Bącela-Spychalska

Abstract

The golden crayfish, *Faxonius luteus*, was identified for the first time in the Black Hills of South Dakota. We collected specimens from three reservoirs and one stream in two adjacent watersheds. The species appears to be established with varying sizes and Form I and Form II males being observed. Records show the home range of *F. luteus* to be over 600 km east of the Black Hills. The lack of historic information on aquatic fauna in the area complicates determining what effects *F. luteus* may have on native and other non-native fauna in the area.

Key words: bait, baitfish, Black Hills, non-native

Introduction

As native denizens of freshwater ecosystems, crayfish can act as bioindicators of community or habitat health and serve as keystone species (Reynolds et al. 2013). However, when crayfish are introduced into non-native habitats and become invasive, there is potential for them to create considerable environmental stress and irreparable shifts in species diversity (Hobbs et al. 1989). For instance, introductions of North American red swamp crayfish, *Procambarus clarkii* (Girard, 1852), and signal crayfish, *Pacifastacus leniusculus* (Dana, 1852), to Europe have had detrimental effects on native European crayfish species resulting from competition and transmission of the crayfish plague-causing pathogen *Aphanomyces astaci* (Schikora, 1903) (Hobbs et al. 1989; Gherardi 2006; Jussila et al. 2015). Within North America, introductions of rusty crayfish, *Faxonius rusticus* (Girard, 1852), have disrupted native crayfish populations and other aquatic communities (Wilson et al. 2004; Olden et al. 2006).

In 2017, the South Dakota Game Fish and Parks Department (SDGFP) removed most restrictions on the use of baitfish, including crayfish, within the Black Hills. Anglers are now allowed to trap and possess crayfish throughout the area, increasing the likelihood that crayfish species will be introduced to new waters (DiStefano et al. 2009; Banha and Anastácio 2015). In addition, while crayfish distributions in some Great Plains States have been intermittently surveyed over the last few decades, they remain poorly known in most of South Dakota, including the Black Hills (Hubert 1988, 2010; Hayer et al. 2011; Schainost 2016; Montana Field Guide 2020). Although crayfish sampling has been nearly non-existent in the Black Hills, a few fishery reports mention crayfish but unfortunately do not include species identifications (Meester 1998). Distribution maps provided by the United States Geological Service do provide information on potential crayfish species in the area by projecting crayfish distribution from hydrological units and point collections where crayfish have been reported (US Geological Survey 2019). According to these maps, crayfish species expected to inhabit the Black Hills are calico crayfish, *F. immunis* (Hagen, 1870), and virile crayfish, *F. virilis* (Hagen, 1870), since their projected distributions either include or are adjacent to the Black Hills, and western plains crayfish, *F. causeyi* (Jester, 1967), by way of planned introductions in 1969 and 1970 (Ford 1971; Friberg 1972, 1974). Due to the changes in regulations and paucity of information on crayfish in the Black Hills, a study on crayfish species distribution commenced in 2018. Objectives of the sampling are to determine 1) what species of crayfish inhabit the area and 2) how widely distributed they are.

Materials and methods

Study area

The Black Hills are an uplifted region in western South Dakota and eastern Wyoming with numerous areas of headwater formations from aquifer leakage and artesian springs (Figure 1, Carter et al. 2002). Geologic structure of the area is complex with granite and metamorphic rock outcrops surrounded by concentric rings of sedimentary rocks descending onto the prairie (Williamson and Carter 2001). The sedimentary formations found within the north and east edges of the uplift area result in localized dewatering (loss zones) in many streams with water returning at lower elevations. The lack of connectivity is typically observed between the high-elevation headwaters and the lower elevation tailwater prairie streams. Most streams in the Black Hills are cold permanent streams supporting non-native salmonids and other coldwater fish species (Schultz et al. 2012). No ponded areas except for beaver dams and artesian spring upwellings existed in the Black Hills until reservoir construction began in the 1930's (Simpson et al. 2015). Since then, reservoir and pond construction throughout the area has been substantial, with over thirty public ponds and reservoirs now in the Black Hills and many more small dams constructed on private properties (Simpson et al. 2015).

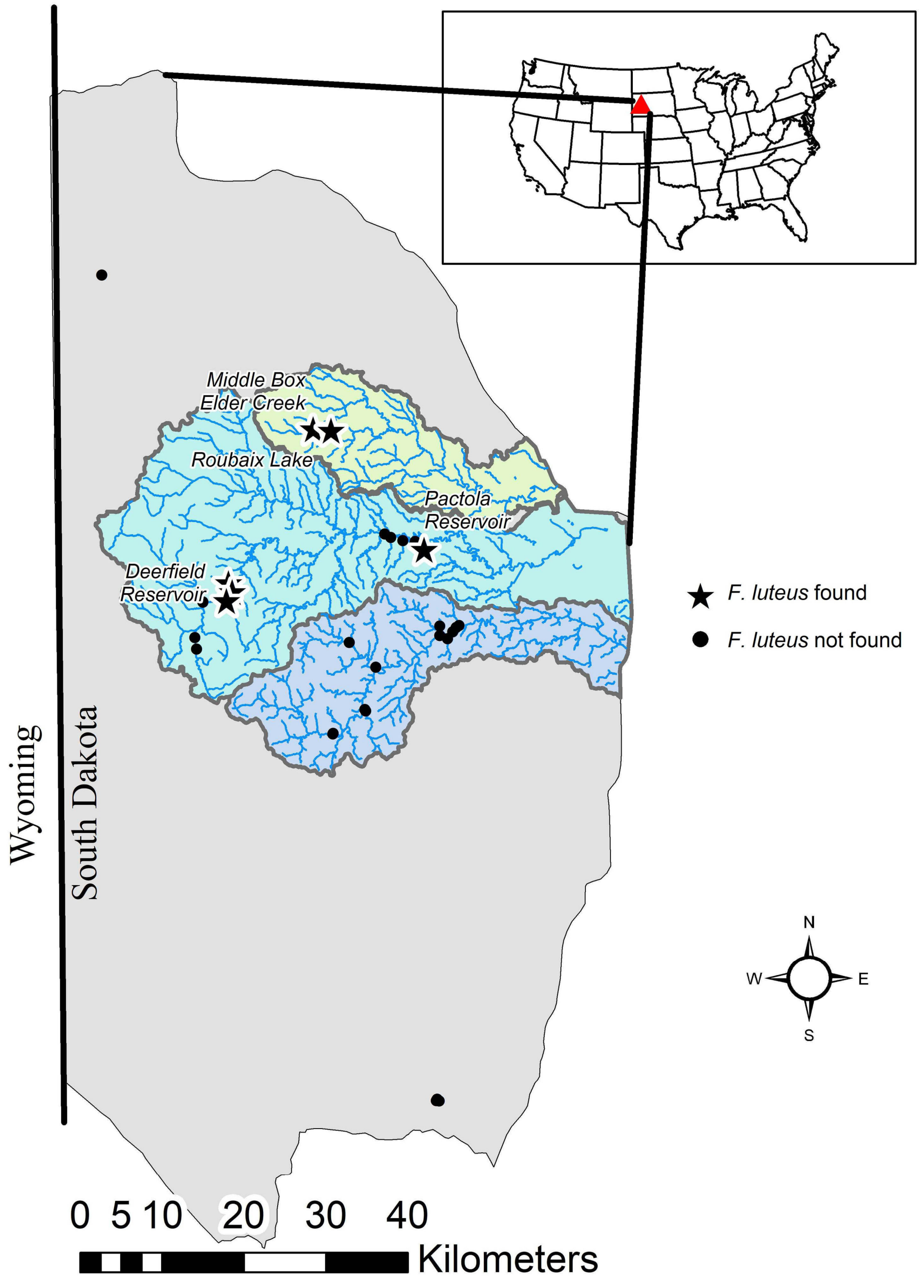

Figure 1. Location and area of the Black Hills (grey) in South Dakota with sample locations (●) and locations where *Faxonius luteus* were collected (★). Boxelder Creek watershed (upper), Rapid Creek watershed (middle) and Spring Creek watershed (lower) are shown.

Sampling

Field sampling occurred between May–August 2018 and May–August 2019 in both reservoirs and streams. During 2018, 13 sites on four lakes and eight sites on four streams were surveyed and in 2019 12 sites on five lakes and two sites on one stream were surveyed. Each reservoir and stream site consisted of a 100 m section along the shoreline or stream. Sampling for both water body types was accomplished using baited traps and dip netting. For each sample site, three square metal traps (30.48 cm × 30.48 cm × 15.24 cm with 1.27 cm mesh) baited with either dry dog food or commercial catfish baits were submerged and fished for approximately 24 hrs. Traps were normally set in stream areas ranging from 20 to 38 cm in depth and in reservoir areas ranging from 30 to 90 cm in depth. Traps were set near each end of the 100 m site and one near the middle of the site. Dip netting was accomplished by walking the entire 100 m site along the reservoir shoreline or in an upstream direction and netting all observed crayfish. Dip nets were trapezoidal in shape with measurements of 11.43 cm wide at the top, 31.75 cm wide at the base, 38.10 cm long and 17.78 cm deep with knotless 0.64 cm mesh. When possible, large rocks were overturned to search for crayfish. When vegetation was encountered, "blind" dip netting was done by vigorously pushing the dip net through the vegetated area. Stream sampling consisted of a minimum of two sample sites for each stream using SDGFP historical fish sampling sites or stream areas readily accessible (e.g., on public land, close to a roadway). Most crayfish were released after species and gender identification. A minimum of one large male assumed to be Form I from each species was preserved in 90% isopropyl alcohol as a voucher for the site. If Form I males were not captured, then at least one Form II male and one large female were kept as a voucher. Species identification of common physical traits was confirmed in the laboratory using the keys by Hobbs (1989) and Taylor et al. (2015). The focus of these surveys was as an inventory (i.e. presence) of crayfish species and measurements were not collected.

Genetics

In order to verify our morphological species identifications and attempt to determine the origin of non-native crayfish, we amplified and sequenced a 458 base pair region of mitochondrial 16S rRNA from a voucher specimen following the methods outlined in Glon et al. (2018). We then used the National Center for Biotechnology Information's (NCBI) Basic Local Alignment Search Tool (BLAST) implemented in Geneious R11 (www.geneious.com) to compare our DNA sequence data to DNA sequences from previous studies that were uploaded to NCBI's GenBank. We used MUSCLE implemented in Geneious to align our voucher sequence and matching sequences from GenBank, then visually inspected the resulting alignment to determine which sequences most resembled ours. We uploaded our new sequence to GenBank (Genbank ID MN964004).

Results

Three crayfish species were collected during this survey: *F. immunis*, *F. virilis* and golden crayfish, *F. luteus* (Creaser, 1933). *Faxonius immunis* and *F. virilis* are thought to be native to the area due to recognized home ranges (Hobbs 1989; Durland 2020). Non-native *F. luteus* (Figure 2) were collected from three different reservoirs and one stream in two different watersheds (Figure 1). *Faxonius luteus* were first collected from Roubaix Lake in the

Figure 2. *Faxonius luteus* specimen collected from Roubaix Lake, 2019. A and B are Form I gonopods. Photographs by Mael Glon.

Boxelder watershed and subsequent sampling revealed Form I and Form II males and various sizes of females immediately below the reservoir in Middle Boxelder Creek. *F. luteus* were also collected in the adjacent Rapid Creek watershed from Deerfield and Pactola Reservoirs by both traps and shoreline sampling (Figure 1).

Our BLAST search revealed that the 16S rRNA sequence of our voucher specimen is identical to the corresponding 458 base pairs of several *F. luteus* GenBank specimens, confirming our identification based on taxonomic keys. Specifically, our sequence matched GenBank IDs AF376483 and

AF376484 from Fetzner and Crandall (2003), which correspond to that study's haplotypes 1 and 2, respectively. Fetzner and Crandall (2003) documented that haplotype 1 was found in specimens from Missouri and Illinois, while haplotype 2 was found only in Missouri specimens. These two haplotypes differ by a single base pair, but the polymorphic site is just outside of the region that was amplified with our primers so we cannot differentiate between these two. Haplotype 1 from Fetzner and Crandall (2003) was also found in specimens collected from Iowa and Minnesota by Wetzel et al. (2004). Lastly, our sample was also identical to GenBank ID KU172581 from Leon et al. (2016), which was obtained from Iowa specimens and is identical to haplotype 1 mentioned above (this sequence is longer than ours, and therefore has the 1 base pair polymorphism that differentiates haplotypes 1 and 2). Due to the broad geographic occurrence of these two haplotypes, we were unable to meaningfully determine a potential basin or even State of origin of the non-native South Dakota *F. luteus* specimens. However, future studies specifically focused on this question could use more sophisticated technology and more widespread sampling to answer this question.

Discussion

Our collections of *F. luteus* in the Black Hills are the first recorded occurrences of this species in South Dakota. The established range of *F. luteus* extends from eastern Kansas throughout much of Missouri and into southeastern Illinois in the Mississippi River mainstem, then into Iowa and southern Minnesota (Daniel 2020). While *F. luteus* is found in the southern portion of the Missouri River mainstem and Black Hills streams are connected to tributaries of the central portion of the Missouri River, no records of the species occur between these two areas. Therefore, it is highly unlikely that the species migrated to the Black Hills naturally. More realistically these populations originated through bait introductions by anglers or pond owners (Kilian et al. 2012; Daniel 2020). However, a previous survey of crayfish in Missouri during which non-native populations of *F. luteus* were also found suggested that this species was not usually sold in the bait trade, leaving the introduction vector for this species in the Black Hills unclear (DiStefano et al. 2015).

While our collections are the first confirmed occurrence of *F. luteus* in the Black Hills, the earliest probable record is a general mention of crayfish during a fish survey at Deerfield Reservoir in 1994 as "very abundant throughout the lake" (South Dakota Game, Fish and Parks, Pierre, South Dakota, *unpublished data*). No identification was completed, but *F. luteus* appearing common throughout the reservoir suggests the species may have existed in the reservoir for some time. Sampling from the current survey also collected *F. immunis* at Deerfield Reservoir, but in fewer numbers (N = 4) and at only two sites, versus *F. luteus* (N = 31) collected at all three sample locations.

Implications of introduced *F. luteus* in the Black Hills are hard to gauge due to lack of historic records on crayfish in the area. While *F. luteus* has been classified as a habitat generalist able to dominate crayfish communities (DiStefano et al. 2003), it appears that few, if any, crayfish species were documented to be established in the Black Hills prior to construction of reservoirs. The purported home range of *F. immunis* suggests that it is most likely native to the area, but the lack of historic information makes it difficult to verify this assertion. In either case, *F. immunis* currently appears to be co-existing with *F. luteus* in our three focal reservoirs, although future studies may be warranted to investigate interactions between these species to identify any detrimental effects.

Any effect of non-native *F. luteus* on native fish or introduced salmonid populations will likely be minimal. The building of reservoirs throughout the Black Hills changed local geography substantially and numerous fish introductions have altered native aquatic communities. Historic fish information showed few species of fish inhabited area streams (Evermann and Cox 1896; Bailey and Allum 1962), and past fish introductions and continued stockings likely have much more influence. The impact of non-native *F. luteus* on non-crayfish invertebrates is also unknown. Whitledge and Rabeni (1997) showed that native *F. luteus* in an Ozark stream can consume significant amounts of benthic invertebrates and may influence lower trophic levels. However, little information is available concerning invertebrate communities where *F. luteus* has been discovered in the Black Hills, so no meaningful comparisons can presently be made to determine if this species is having any impacts.

Currently, the central portion of the Black Hills of South Dakota has been the focus of our surveys. Outcomes of this study necessitate continued sampling of the northern and southern portions as well. This sampling will help determine if any additional Black Hills watersheds contain non-native *F. luteus* and may provide additional data that can be used to determine the origin and potential ecological impacts of this species. Future sampling will also provide a much-needed inventory of other native and non-native crayfishes in this part of South Dakota which has been largely overlooked to date.

Acknowledgements

We thank Bill Miller and Ryan Richards for their assistance during field investigations. We also thank anonymous reviewers for valuable comments on earlier versions of this paper and Greg Simpson for initial review and providing the distribution map.

Funding Declaration

This study was supported by the South Dakota Department of Game, Fish and Parks.

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