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Trout Redd Locations in Two Streams in the Black Hills, South Dakota, USA

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Abstract

This study examined the spatial and temporal characteristics of brook trout *Salvelinus fontinalis* and brown trout *Salmo trutta* redds in two sites from two creeks in the Black Hills of South Dakota, USA. Spawning began in both streams in early October and continued through mid-November. Significant spatial clustering was only observed on both Rapid Creek sites, whereas random redd development was observed in both of the sites on Box Elder Creek. Based on visual observations, brown trout redds were more abundant in Rapid Creek, whereas brook trout redds were more abundant in Box Elder Creek. Differences in redd clustering could be due to species-specific, geological, or hydrological differences between the creeks.

Keywords

Brook Trout, Brown Trout, Redds, South Dakota, Spawning

1. Introduction

Trout and salmon, family Salmonidae, generally spawn in a redd, a collection of gravel pit nests [1]. Brown trout *Salmo trutta* and brook trout *Salvelinus fontinalis* spawn in the fall [2], with brown trout typically spawning slightly later and for a shorter period of time than brook trout [2] [3]. When these two species occur in the same stream, both intraspecific and interspecific redd superimposition frequently occurs [4]. Redd abundance and distribution have been used to monitor abundance and populations trends [5] [6] [7] [8]. Redd counts can be particularly good indicators of effective population sizes [9].

Trout redd location in streams can be influenced by several factors, including water depth, water velocity, substrate size, and stream width [10]. Brook trout appear to prefer to build redds in areas of groundwater seepage [11] [12] [13] whereas brown trout prefer locations with coarser gravel and faster moving water [11]. Water depth appears to be determinant of brown trout redd locations as well [14].

Although not native to the Black Hills of South Dakota (USA), brook trout and brown trout now inhabit nearly all of the 1287 km of streams with suitable habitat [15]. The populations of these fish, the primary sport fish species in the coldwater habitat present in Black Hills streams, are sustained primarily through natural reproduction and recruitment [16] [17]. Despite their presence in the Black Hills since 1886 [18], little is known about the timing of redd construction or redd distribution of brook trout and brown trout in Black Hills streams. This information is needed to preserve these important life history areas from inadvertent disturbance during stream habitat work or from other anthropomorphic changes. In addition, climatic changes may impact the future timing of trout spawning [13], necessitating the collection of current temporal data. Thus, the objective of this study was to provide initial information on the timing of redd development and redd spatial orientation in the Black Hills by focusing on two known spawning areas in two representative streams.

2. Study Areas

Two sections of Rapid Creek and two sections of Boxelder Creek in the Black Hills of South Dakota, USA, were included in this study (**Figure 1**). The first Rapid Creek section was within the city of Rapid City, and comprised the stream

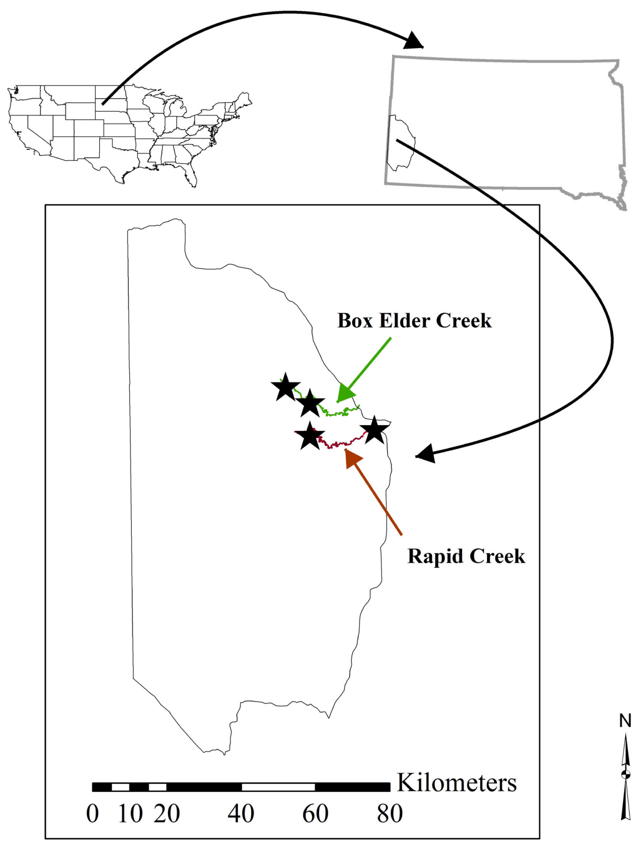

Figure 1. Redd survey locations in two creeks in the Black Hills of South Dakota, USA.

stretch between the street bridge at Sheridan Lake Road and the street bridge at Jackson Boulevard, a distance of approximately 1538 m. A second, upstream section of Rapid Creek was also studied, spanning a distance of 2183 m from the bridge at Placerville Church Camp to the first trestle at Pactola Basin. There were two sites on Boxelder Creek, with the first encompassing the stream reach within the Steamboat Rock picnic area. The other site began upstream at the Box Elder Creek campground and ended 1612 m upstream.

3. Materials and Methods

3.1. Redd Site Location and Recording

This initial survey of redd location started on October 14, 2014 and continued for the next four weeks at which point spawning activities ceased. The methods used to locate and identify redds were similar to those used by Dunham *et al.* [19]. Each creek section was surveyed for redds five times over a four week period, with redd locations recorded using Trimble (Sunnyvale, California, USA) Global Positioning System units. Only data from confirmed redds were included to minimize potential observer error [20]. The species of fish on or near the redd, if it could be determined, was noted. Redd location data was analyzed using ArcGIS (Esri, Redlands, California, USA) [21].

3.2. Redd Distribution Analysis

Global Moran's I (Equation (1)) was used to determine the extent of redd spatial autocorrelation with a range of 1 to −1, with the positive indicating clustering and the negative indicating dispersion.

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

where z_i is the deviation of an attribute for feature i from its mean ($x_i - \bar{X}$), $W_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features, and S_0 is the aggregate of all the spatial weights.

4. Results

4.1. Redd Location and Numbers

The number of redds increased at each study site in each creek from the start to the end of the four week study period. By the end of the study period, the number of trout redds differed among the sites and between the creeks. There were 253 redds at the Rapid Creek site in town and 143 at Rapid Creek near Placerville. Only 16 redds were detected in Boxelder Creek at the Steamboat Rock site, with 53 redds at the Box Elder Campground. Based on visual observations, brown trout redds were more abundant in Rapid Creek, whereas brook trout redds were more abundant in Box Elder Creek. Spawning appeared to have ceased by the last sampling period, with fish notably absent in the spawning areas.

4.2. Redd Clustering

Redd construction showed spatially different trends at each of the four sites (Figures 2-5). Redds were significantly clustered in Rapid Creek, with a lower clustering tendency in the Rapid City site (I = 0.074, Z = 4.756, $p < 0.001$) compared to the upstream location (I = 0.758, Z = 20.70, $p < 0.001$). No significantly clustering was observed in either of the Box Elder creek sites (Steamboat Rock: I = −0.124, Z = −0.829, $p = 0.404$; upstream: I = 0.044, Z =0.907, $p = 0.365$).

5. Discussion

This is the first study to document redd locations in any creeks in the Black Hills of South Dakota, which may help protect these areas from possible degradation due to angler disturbance, road construction, or other anthropomorphic activities. It is also the first to document the time of spawning in the Black Hills. Anglers in particular should avoid wading in areas where redds are present [22].

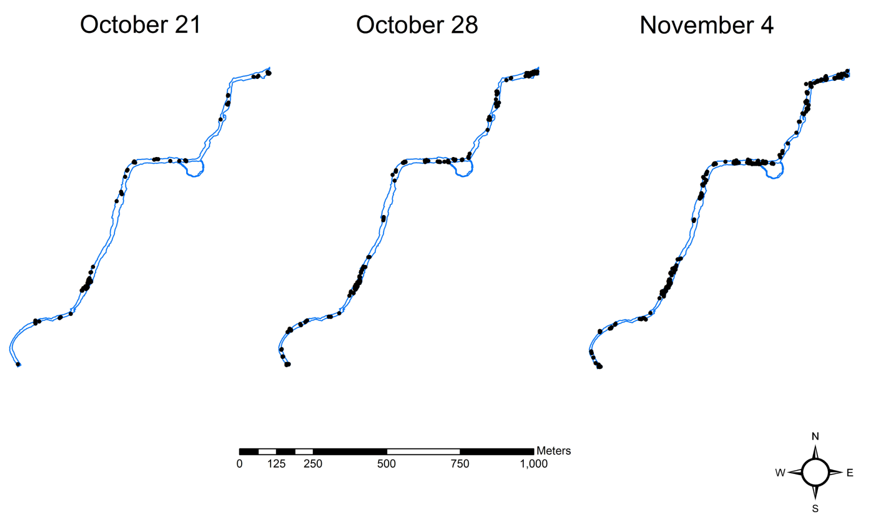

Figure 2. Trout redd development in Rapid Creek within Rapid City.

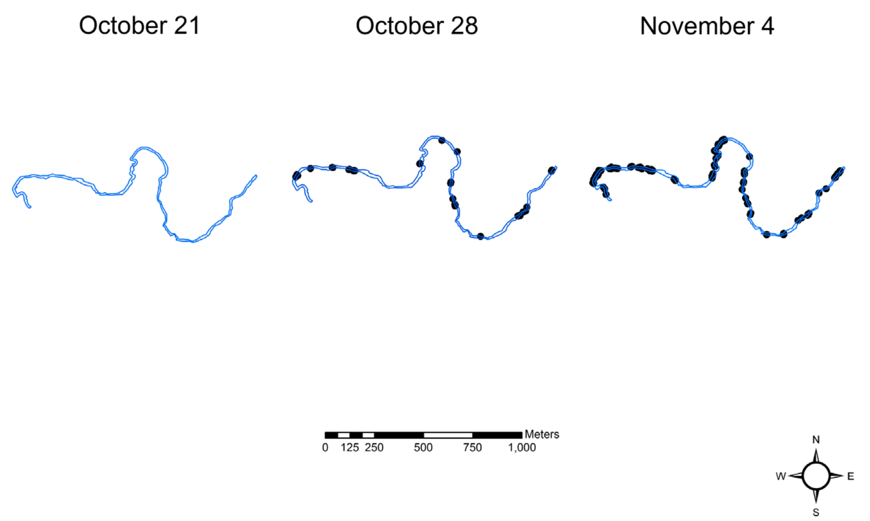

Figure 3. Trout redd development in Rapid Creek at Placerville.

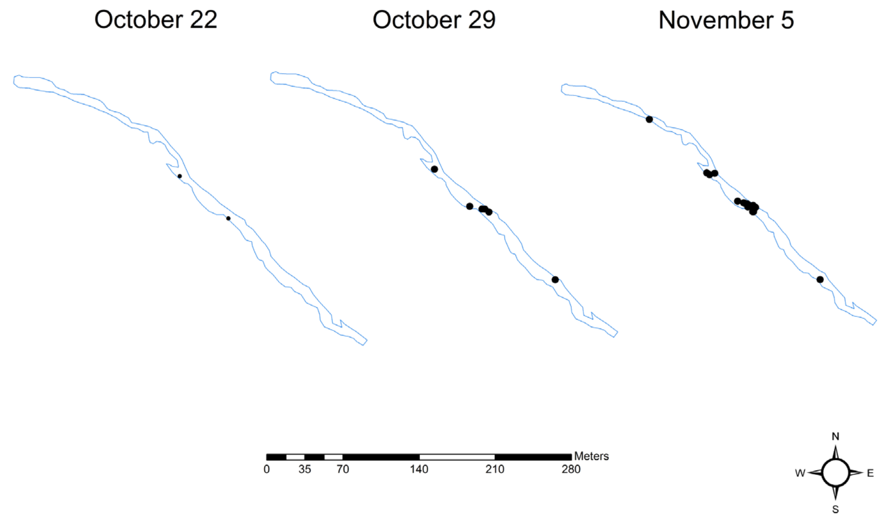

Figure 4. Trout redd development in Box Elder Creek at Steamboat Rock.

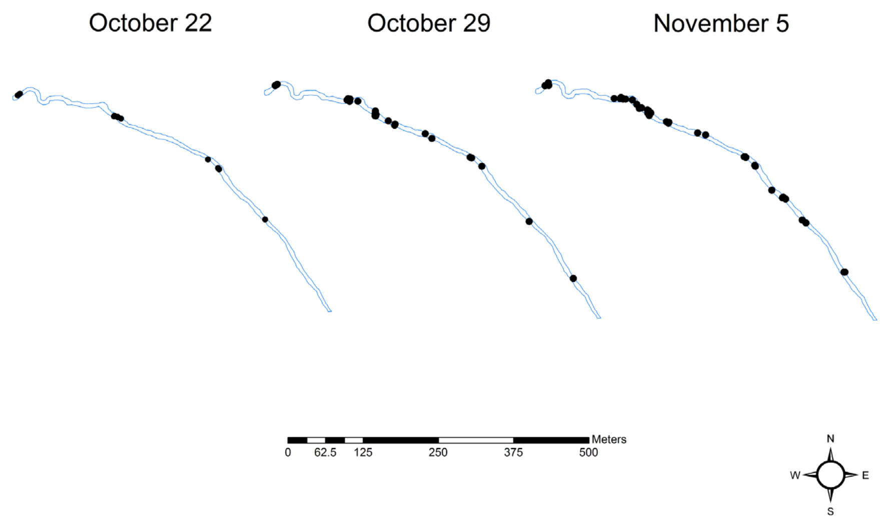

Figure 5. Trout redd development in Box Elder Creek at Box Elder Campground.

For brown trout and brook trout, spawning began in early October and ended in mid-November, which is within the range of dates reported for both species in the United States [2] [3]. Because general spawning times are relatively consistent [12], the spawning times in this paper are likely representative of brook and brown trout in the Black Hills and are not unique to 2014. However, it is possible that spawning times could be affected by water temperature changes resulting from climate change [13].

Because of the overlap in spawning times between these two species, redd superimposition may be occurring [13]. Superimposition is the reuse of redd sites by later spawning fish of either the same, or different species, and it is common in salmonids [24] [25]. Redd superimposition does not indicate limited spawning habitat [23] [26], and the effects of redd clustering on superimposition are unknown. Brown trout superimposition on brook trout redds may be detrimental to brook trout populations [24] [27].

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The differences observed between Rapid and Boxelder Creek in redd numbers and clustering are likely due to biological, geological, and hydrological factors. Different fish populations exist in each of the creeks. In the specific reaches of Rapid Creek that were sampled, brown trout are the most prevalent species; whereas, in Box Elder Creek brook trout are more common [28]. In general, brown trout prefer spawning sites with higher velocity water, whereas brook trout prefer lower water velocities [2], and Rapid Creek typically has much higher water velocity than Box Elder Creek [28]. In the Black Hills, there is extensive interaction between groundwater and surface water [29], with considerable groundwater upwelling within streams [30]. Although brown trout will build nests in areas of groundwater upwelling, they do not show a distinct preference for such areas [31]. In contrast, brook trout redds have been observed to be closely associated with upwelling groundwater [12] [32] [33] [34] [35]. Although stream hydrology was not evaluated in this study, it is possible that such groundwater interactions may be more common throughout Box Elder Creek and more limited in the sampled reaches of Rapid Creek, which may explain at least in part the increased number of brook trout redds in Box Elder Creek. Spawning substrate, such as the size of stream bed gravel, appears to have a substantial influence on redd site selection in brown trout [36] [37]. The larger number of redds at the Rapid Creek site in Rapid City compared to the Placerville site may be due to the relatively large amount of gravel in the Rapid City site compared to a substrate of nearly exclusively shale at the Placerville site.

Although the presence of redds does not necessarily indicate successful reproduction and recruitment, redd counts have been used to assess general trends in salmonid populations [38] [39] [40]. Redd counts have several advantages over other fish population survey methods [20], and would be much less expensive than the backpack electrofishing surveys historically used in the Black Hills [28].

Because observations from only one year were included in this study, it is unknown if redd locations would change in subsequent years, particularly if hydrological characteristics changed. In addition, the relative inexperience of the observers may have influenced the results [20], although any such errors were likely minor given the size of the creeks studied and extensive observer training. The survey design was within the parameters suggested by Gallagher *et al.* [41], with sampling every week throughout the spawning period. Despite these caveats, the redd data from this study are likely an accurate reflection of the number of redds and timing of redd construction in the two sites on Rapid Creek and Boxelder Creek.

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