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# SEASONAL MOVEMENTS OF NATIVE AND INTRODUCED CATOSTOMIDS IN THE BIG SANDY RIVER, WYOMING

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ABSTRACT—During 2006–2007, we studied movements of native bluehead suckers (*Catostomus discobolus*) and flannelmouth suckers (*C. latipinnis*), and non-native white suckers (*C. commersonii*) and longnose suckers (*C. catostomus*) in the Big Sandy River, Wyoming. Radiotransmitters were surgically implanted into 20–22 fish of each species in September and October 2006. Movements of all four species in autumn and winter were short with most fish remaining ≤2 km from locations where they were captured initially. Bluehead suckers and flannelmouth suckers began movements downstream in mid-to-late April and returned upstream to locations ≤2 km from their original locations by early summer. White suckers did not make substantial movements during spring, whereas longnose suckers made movements upstream during mid-June and returned downstream by early July. During their estimated spawning periods, longnose suckers used upstream portions, bluehead suckers and white suckers used middle portions, and flannelmouth suckers used downstream portions of the study area.

RESUMEN—Durante 2006–2007, estudiamos los traslados de dos especies de matalotes nativos, matalotes de cabeza azul (*Catostomus discobolus*) y matalotes boca de franela (*C. latipinnis*), y dos especies no nativas, matalotes blancos (*C. commersonii*) y matalotes (*C. catostomus*) en el río Big Sandy, en Wyoming. Implantamos quirúrgicamente radiotransmisores en 20–22 peces de cada especie en septiembre y octubre del 2006. Los traslados de las cuatro especies durante otoño e invierno fueron cortos, la mayoría de los peces se mantuvo ≤2 km del sitio de captura inicial. Los matalotes cabeza azul y los boca de franela empezaron a trasladarse río abajo de mediados a finales de abril, y regresaron a sitios ≤2 km de sus sitios originales temprano en el verano. Los matalotes blancos no hicieron traslados sustanciales durante la primavera, mientras que los matalotes *C. catostomus* se trasladaron río arriba a mediados de junio para regresar río abajo hacia julio temprano. Durante la época estimada del desove, los matalotes *C. catostomus* usaron las secciones río arriba, los matalotes blancos y los de cabeza azul usaron las secciones medias, y los matalotes boca de franela usaron las secciones río abajo del sitio de estudio.

Bluehead suckers (*Catostomus discobolus*) and flannelmouth suckers (*C. latipinnis*) are native to the Colorado River Basin where they were once abundant. Historic ranges of these two species have been reduced with loss of habitat cited as the primary cause of their decline (McAda, 1977; Mueller and Marsh, 2002). Increasing hybridization of these two native catostomids with introduced catostomids in the Colorado River Basin also threatens their continued existence (McAda, 1977; Cook et al., 2005; Compton, 2007; Gill et al., 2007; McDonald et al., 2008).

Both bluehead suckers and flannelmouth suckers are native to the Green River drainage in Wyoming and are species of concern within the state. In 2002, the Wyoming Game and Fish Department began a survey of native fishes to assess current distributions within the Green River drainage of Wyoming (Gill et al., 2007). As a result of the survey, the Big Sandy River was identified as a potential conservation area for bluehead suckers and flannelmouth suckers. However, the Big Sandy River also contains populations of introduced white suckers (*C. commersonii*) and longnose suckers (*C. catostomus*).

Knowledge of movements of catostomids in the Big Sandy River can provide information useful in conservation of the two native species (Northcote, 1997; Lucas and Baras, 2001). A variety of movement patterns by bluehead suckers have been described, including no spawning migrations, short spawning migrations into tributary streams, and long spawning migrations in rivers (Maddux and Kepner, 1988; Beatty, 2005; Compton et al., 2008). Flannelmouth suckers move upstream to spawn, and then return downstream (Chart and Bergersen, 1992; Compton et al., 2008). Movements of white suckers from reservoirs or large streams into tributaries, during March–June have been described (Geen et al., 1966; Barton, 1980; Corbett and Powles, 1983; Beatty, 2005; Compton et al., 2008). Brown et al. (2001) detected movements by white suckers in winter only during flood events and the breakup of ice. Little information is available on movements of longnose suckers, but spawning migrations out of lakes and into tributary streams have been described (Brown and Graham, 1954; Geen et al., 1966; Barton, 1980; Dion et al., 1994). The purpose of our study was to describe seasonal movements of native bluehead suckers and flannelmouth suckers, and introduced white suckers and longnose suckers in the Big Sandy River of Wyoming.

Materials and Methods—The Big Sandy River is a tributary of the Green River in Wyoming, draining 4,688 km$^2$. It originates on the southwestern slope of the Wind River Mountains and flows southwestward onto semi-arid plains, where the segment that we studied occurred, and sagebrush (*Artemisia*) was the most prevalent vegetation. Elevation of the upstream boundary of the study area was 2,186 m above mean sea level and was selected because bluehead suckers, flannelmouth suckers, and white suckers were not captured upstream of that location during a recent survey by personnel of the Wyoming Game and Fish Department (Gill et al., 2007). The downstream boundary of the study area was the United States Geological Survey gauging station 09213500 near the town of Farson, Sweetwater County, Wyoming, immediately upstream from Big Sandy Reservoir at an elevation of 2,064 m above mean sea level. The downstream end of the study area was 88 stream kilometers from the upstream boundary. Within the study area, the river has perennial flow and a mean wetted width of 15 m during late-summer base flow. Sculpin Creek was the only perennial tributary to the Big Sandy River within the study area.

We radio-tagged bluehead suckers, flannelmouth suckers, white suckers, and longnose suckers that did not exhibit morphological features indicative of hybridization. We used morphological features described by Baxter and Simon (1970) to identify each species. Recent research confirms the accuracy of features we used in identification of species and hybrids of catostomids (Quist et al., 2009). Fish were captured by electrofishing pools throughout the study area during September and October 2006. Radiotransmitters (Model MCFT-3EM; Lotek Wireless Fish and Wildlife Monitoring, Newmarket, Ontario) were set at three frequencies (162.206, 162.419, and 162.581 MHz) with individual codes for identification. To ensure that the transmitter was $<2\%$ of the body weight of the fish (Winter, 1996), fish used had a body mass $\geq 420$ g. We used the shielded-needle technique to implant transmitters into captured fish (Ross and Kleiner, 1982). After surgery, fish were held in a mesh cage in the river channel and considered recovered from surgery when they swam upright and attempted to evade handling. Fish were released subsequently in the pool where they were captured.

During October 2006–July 2007, we tracked radiotagged fish by walking along the bank or floating the river using a scanning receiver (SRX 400A; Lotek Wireless Fish and Wildlife Monitoring, Newmarket, Ontario) and a bi-directional loop antenna (50 cm wide). Trangulation of exact locations of fish was not used due to interference from multiple transmitters and because triangulation did not improve precision in the narrow channel. Tracking occurred during daylight hours, twice a month in autumn, once a month in winter, and weekly in spring and early summer. We defined seasons based on discharge and ice. Autumn was the period with base flows and declining water temperatures until surface ice covered the study area (i.e., September–November 2006; tracking events 1–3). Winter was when surface ice covered the study area (i.e., December 2006-mid-March 2007; tracking events 4–7). Spring was from the time surface ice broke up through spring runoff, (i.e., mid–March–June 2007; tracking events 8–16). Summer began when discharge declined to1.8 m$^3$/s at the end of June 2007 (tracking events 17–18).

A tracking event was the period during which a fish was located and a tracking interval was the time between locating individual fish on successive tracking events. Linear range was distance (meters) between locations of an individual fish during a tracking interval (Clapp et al., 1990). Rate of movement was distance moved per day by an individual fish during a tracking interval. Net movement was the upstream or downstream linear range of an individual fish during a tracking interval. Positive values indicated net movement upstream and negative values indicated net movement downstream. A Mann-Whitney *U*-test was used to test for differences in linear ranges, rates of movement, and net movements among successive tracking intervals for each species (Ramsey and Schafer, 2002). A Kruskal-Wallis test was used to test for differences among species for each tracking interval (Ramsey and Schafer, 2002) and the False Discovery Rate was used to control the proportion of false positives that occur with multiple tests (Benjamini and Hochberg, 1995; Storey, 2002). Significant *q*-values are reported with significance at an error rate $<0.05$.

Results—We implanted 22 bluehead suckers, 22 flannelmouth suckers, 21 white suckers, and 20 longnose suckers with radiotransmitters (Fig. 1). There were three tracking events during

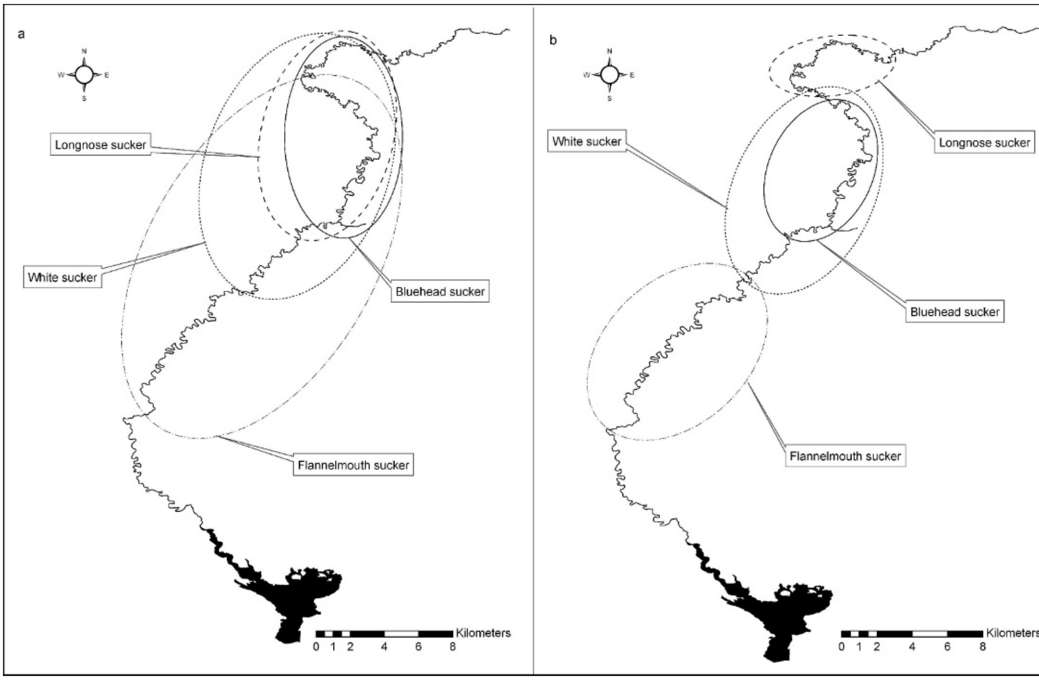


FIG. 1—The Big Sandy River, Wyoming, with ovals containing: a) locations where radiotransmitters were implanted in fish; and b) 50% of locations where fish occurred during the estimated peak of spawning for bluehead suckers (*Catostomus discobolus*), flannelmouth suckers (*C. latipinnis*), white suckers (*C. commersonii*), and longnose suckers (*C. catostomus*).

autumn (tracking events 1–3), four during winter (tracking events 4–7), nine during spring (tracking events 8–16), and two during early summer (tracking events 17–18).

Patterns of movement of species differed temporally. Of locations in autumn and winter, 85–97% were ≤2 km of their previous known location, although there were increases in linear ranges and rates of movement after onset of winter (i.e., ice cover) with movements that were predominantly downstream. Linear ranges and movements of all four species increased during spring (Fig. 2). Bluehead suckers began movements downstream in mid-to-late April, after which linear ranges and rates of movement gradually declined into early July when both measures increased with no apparent directional pattern of movement. Flannelmouth suckers made long movements downstream in mid-to-late April, began movements upstream in mid-to-late May, and continued upstream through early July. White suckers showed small non-directional increases in linear ranges and rates of movement in early June. Longnose suckers began non-directional movements in early spring followed by movements that were predominantly upstream during late spring and early summer.

There were significant differences among the four species relative to linear ranges, rates of movement, and net movements during several tracking intervals (Table 1). Bluehead suckers had significantly smaller linear ranges than other species in mid-to-late October (tracking interval 1–2). Flannelmouth suckers had significantly longer linear ranges, higher rates of movement, and greater net movements (downstream) than other species from mid-April to early May (Fig. 2; tracking intervals 9–10, 10–11, and 11–12).

Only one radio-tagged fish, a flannelmouth sucker, was located outside of the study area. This individual moved downstream from the United States Geological Survey gauging station during spring and was in Big Sandy Reservoir.

There was little spatial segregation by the four species during autumn, winter, or summer. However, during spring, longnose suckers used

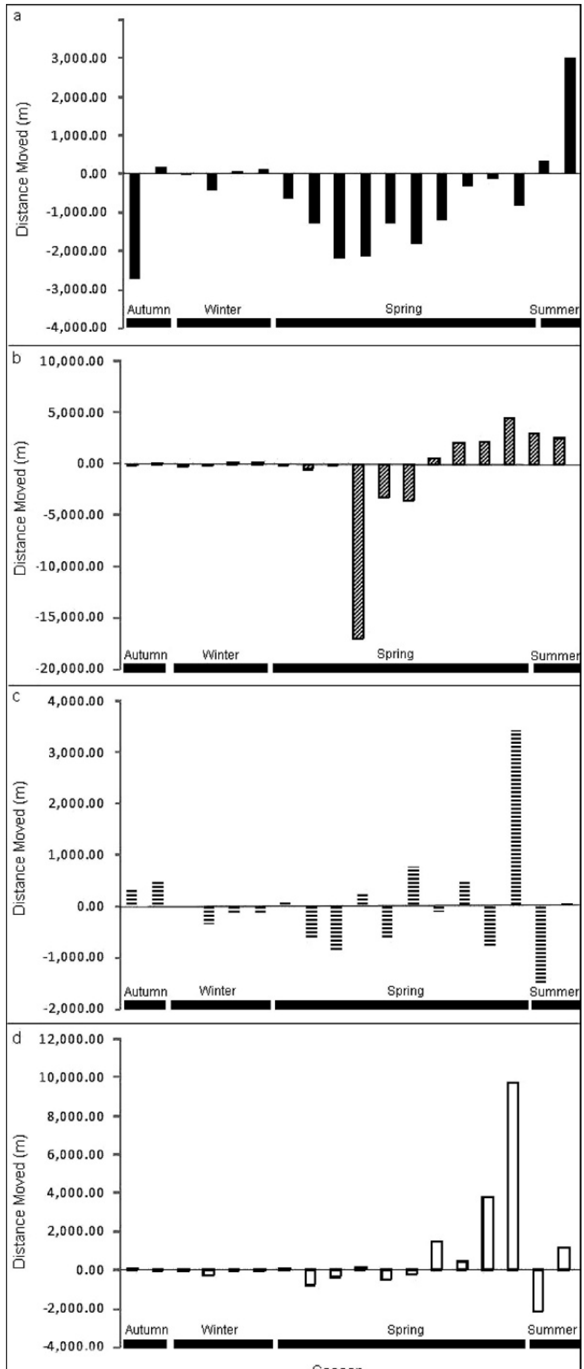


FIG. 2—Distances moved (m) by a) bluehead suckers (*Catostomus discobolus*), b) flannelmouth suckers (*C. latipinnis*), c) white suckers (*C. commersonii*), and d) longnose suckers (*C. catostomus*) between consecutive locations during autumn (8 October–17 November 2006), winter (28 November 2006–8 March 2007), spring (2 April–23 June 2007), and summer (25 June–12 July 2007). Positive values indicate movement upstream and negative values indicate movement downstream. Note differences in scale on Y-axis among species.

TABLE 1—Medians of frequency distributions for linear ranges (distance between locations of fish within a tracking interval), rates of movement (distance moved each day), and net movements (upstream or downstream linear range of a fish during a tracking interval) of individual bluehead suckers (*Catostomus discobolus*), flannelmouth suckers (*C. latipinnis*), white suckers (*C. commersonii*), and longnose suckers (*C. catostomus*) during tracking intervals. Only significant *q*-values derived from Mann-Whitney *U*-tests for differences among species are shown.

| Tracking interval | Species | | | | *q*-value |
|---|---|---|---|---|---|
| | Bluehead sucker | Flannelmouth sucker | White sucker | Longnose sucker | |
| Linear range (m) | | | | | |
| 1–2 | 8[a] | 213 | 187 | 20 | 0.003 |
| 2–3 | 7 | 5 | 6 | 2 | |
| 3–4 | 193 | 74 | 176 | 132 | |
| 4–5 | 741 | 503 | 323 | 466 | |
| 5–6 | 333 | 104 | 69 | 182 | |
| 6–7 | 197 | 81 | 37 | 150 | |
| 7–8 | 942 | 251 | 153 | 614 | |
| 8–9 | 31 | 137 | 96 | 29 | |
| 9–10 | 927 | 17,034[a] | 380 | 678 | 0.007 |
| 10–11 | 883 | 3,826[b] | 275 | 373 | 0.010 |
| 11–12 | 597 | 2,942[b] | 134 | 1,815 | 0.013 |
| 12–13 | 142 | 680 | 452 | 135 | |
| 13–14 | 264 | 2,009 | 52 | 105 | |
| 14–15 | 159 | 890 | 2,615 | 462 | |
| 15–16 | 64 | 4,185 | 2,056 | 6,788 | |
| 16–17 | 111 | 1,888 | 48 | 23 | |
| 17–18 | 3,423 | 866 | 16 | 18 | |
| Rate of movement (m) | | | | | |
| 1–2 | 1 | 14 | 11 | 2 | |
| 2–3 | 1 | 0 | 0 | 0 | |
| 3–4 | 12 | 4 | 9 | 6 | |
| 4–5 | 18 | 12 | 8 | 11 | |
| 5–6 | 11 | 4 | 2 | 6 | |
| 6–7 | 7 | 3 | 1 | 6 | |
| 7–8 | 33 | 10 | 5 | 23 | |
| 8–9 | 1 | 5 | 5 | 2 | |
| 9–10 | 116 | 1,629[a] | 30 | 60 | 0.003 |
| 10–11 | 110 | 478[a] | 39 | 60 | 0.007 |
| 11–12 | 92 | 738[c] | 27 | 259 | 0.010 |
| 12–13 | 17 | 119 | 57 | 17 | |
| 13–14 | 44 | 419 | 9 | 17 | |
| 14–15 | 23 | 127 | 374 | 66 | |
| 15–16 | 4 | 279 | 129 | 377 | |
| 16–17 | 15 | 378 | 7 | 5 | |
| 17–18 | 298 | 110 | 1 | 1 | |
| Net movement (m) | | | | | |
| 1–2 | 0 | 0 | 168 | −5 | |
| 2–3 | 0 | 0 | −1 | 0 | |
| 3–4 | −109 | −14 | −4 | −94 | |
| 4–5 | −40 | 54 | −10 | −7 | |
| 5–6 | 23 | 79 | 39 | −31 | |
| 6–7 | −18 | −11 | −12 | −20 | |
| 7–8 | −942 | −251 | 41 | −26 | |
| 8–9 | −8 | −3 | −11 | −11 | |
| 9–10 | −449[d] | −17,034[a] | 1 | 399 | 0.003 |

Table 1—Continued.

| Tracking interval | Species | | | | *q*-value |
|---|---|---|---|---|---|
| | Bluehead sucker | Flannelmouth sucker | White sucker | Longnose sucker | |
| 10–11 | −883 | −1,187 | −76 | −40 | |
| 11–12 | −344 | −877 | 37 | 1,065 | |
| 12–13 | −108 | 23 | −187 | −8 | |
| 13–14 | −86 | 709 | −3 | 58 | |
| 14–15 | 2 | 4 | 468 | 54 | |
| 15–16 | −4 | 756 | 24 | 6,788 | |
| 16–17 | −24 | 1,888 | 5 | −23 | |
| 17–18 | −7 | 756 | 16 | 1 | |

[a] Species is significantly different from all other species.
[b] Species is significantly different from white and longnose suckers.
[c] Species is significantly different from bluehead and white suckers.
[d] Species is significantly different from the longnose sucker.

the upstream portion, bluehead suckers and white suckers used the middle portion, and flannelmouth suckers used the downstream portion of the study area (Fig. 1). Nevertheless, there was overlap among ranges of the four species during the spawning season.

Discussion—Locations of bluehead suckers, flannelmouth suckers, white suckers, and longnose suckers in autumn and winter generally were ≤2 km from the previous location, indicating relatively sedentary lifestyles during autumn and winter, similar to what has been observed in other studies of white suckers (Brown et al., 2007). However, all four species displayed increased activity at the onset of winter when cover by ice was complete or nearly complete. These increased movements may have been due to improved protection from predation with the formation of ice. Fish were able to move into shallower, slower-velocity areas that might have been undesirable during autumn due to high visibility to avian predators.

Movements of bluehead suckers and flannelmouth suckers downstream in the Big Sandy River coincided with increasing spring flow. Patterns of movement downstream during spring have not been observed in other studies of bluehead suckers or flannelmouth suckers, whereas patterns of movement upstream have been described (Chart and Bergersen, 1992; Weiss et al., 1998; Compton et al., 2008). Movements of bluehead suckers and flannelmouth suckers downstream in the Big Sandy River during spring may have been associated with more suitable temperatures in the downstream portion of the study area. Although water temperature was not collected during our study, previous data on the Big Sandy River indicated that spring-time temperatures increase gradually with progression downstream (Sweet, 2007). Despite movements downstream by both species, bluehead suckers remained farther upstream than flannelmouth suckers. The upstream portion of the study area had more rock substrate, while the downstream portion was dominated by sand substrate (Sweet, 2007). The range of flannelmouth suckers during spring extended into the downstream portion with predominately sand substrate. Other studies have indicated the importance of rock substrate to bluehead suckers (Compton, 2007; Bower et al., 2008).

Movements by bluehead suckers and flannelmouth suckers in spring in the Big Sandy River indicated that spawning began in mid-to-late April and was concluded by early July. This was consistent with other studies describing spawning of these two species (McAda, 1977; Maddux and Kepner, 1988; Weiss et al., 1998; Chart and Bergersen, 1992; Compton et al., 2008). Flannelmouth suckers displayed greatest linear movements and highest rates of movement of the four species of catostomids in the Big Sandy River with median rates of movement in spring up to three times greater than for other species.

White suckers in the Big Sandy River moved little during the study with movements typically <10 km from where they were captured initially. Barton (1980), Corbett and Powles (1983), and Wakefield and Beckman (2005) described movements upstream to spawning areas by white suckers, unlike our observations of this species in the Big Sandy River. White suckers are generalists in their habitat needs and it may not be necessary for them to seek discrete areas to spawn and complete their life cycle within the Big Sandy River. Lack of movements by white suckers in spring made it difficult to estimate their time of spawning in the Big Sandy River. However, movements of two white suckers into Sculpin Creek during mid-May provided some indication of when spawning occurred. Also, observations of untagged, dead, or dying white suckers, believed to be post-spawning mortalities, were seen in the river at the end of June. Other studies have described spawning by white suckers from mid-March to late June in various systems (Barton, 1980; Corbett and Powles, 1983; Beatty, 2005; Wakefield and Beckman, 2005).

Movement upstream by longnose suckers in the Big Sandy River occurred during mid-June. Migrations upstream to spawn by longnose suckers also have been observed in other systems (Brown and Graham, 1954; Harris, 1962; Bailey, 1969; Dion et al., 1994; Barton, 1980). Rock substrate and increased velocities of water in the upper portion of the study area (Sweet, 2007) may have been a factor in movement of longnose suckers upstream. Patterns of movement of longnose suckers in spring indicated that spawning began in mid-to-late April, peaked in mid-June, and was completed by early July. Studies in other systems described spawning from mid-April to mid-July (Brown and Graham, 1954; Harris, 1962; Bailey, 1969).

There was no difference in timing of movements associated with spawning between bluehead suckers and flannelmouth suckers in the Big Sandy River, but temporal segregation between these species has been described in other systems, with flannelmouth suckers spawning earlier than bluehead suckers (Maddux and Kepner, 1988; Weiss et al., 1998; Beatty, 2005; Compton et al., 2008). Previous research has suggested that different times of spawning by bluehead suckers and flannelmouth suckers may create a temporal barrier that contributes to isolation of species (Maddux and Kepner, 1988; Weiss et al., 1998). Although no temporal segregation was observed in the Big Sandy River, there was evidence of spatial segregation during spawning. Bluehead suckers used segments upstream of, and probably cooler than, those used by flannelmouth suckers. Genetic isolation between these two species in the Big Sandy River might be facilitated by spatial segregation during spawning in contrast to temporal segregation.

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