SUMMER FOOD HABITS AND TROPHIC OVERLAP OF ROUNDTAIL CHUB AND CREEK CHUB IN MUDDY CREEK, WYOMING

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ABSTRACT—Native fishes of the Upper Colorado River Basin have experienced substantial declines in abundance and distribution, and are extirpated from most of Wyoming. Muddy Creek, in south-central Wyoming (Little Snake River watershed), contains sympatric populations of native roundtail chub (*Gila robusta*), bluehead sucker, (*Catostomus discobolus*), and flannelmouth sucker (*C. latipinnis*), and represents an area of high conservation concern because it is the only area known to have sympatric populations of all 3 species in Wyoming. However, introduced creek chub (*Semotilus atromaculatus*) are abundant and might have a negative influence on native fishes. We assessed summer food habits of roundtail chub and creek chub to provide information on the ecology of each species and obtain insight on potential trophic overlap. Roundtail chub and creek chub seemed to be opportunistic generalists that consumed a diverse array of food items. Stomach contents of both species were dominated by plant material, aquatic and terrestrial insects, and fishes, but also included gastropods and mussels. Stomach contents were similar between species, indicating high trophic overlap. No length-related patterns in diet were observed for either species. These results suggest that creek chubs have the potential to adversely influence the roundtail chub population through competition for food and the native fish assemblage through predation.

RESUMEN—Peces nativos de Upper Colorado River Basin han experimentado una decadencia substancial en abundancia y distribución, y han sido eliminados de la mayor parte del Estado de Wyoming. Muddy Creek, en la parte sur central de Wyoming (la cuenca del Little Snake River), contiene poblaciones simpátricas del charalito aleta redonda (*Gila robusta),* y de los matalotes *Catostomus discobolus,* y *C. latipinnis* y representa un área de alta preocupación para la conservación debido a que es la única área conocida que tiene poblaciones simpátricas de las tres especies en Wyoming. Sin embargo, la especie exótica *Semotilus atromaculatus,* es abundante y puede tener una influencia negativa en los peces nativos. Analizamos los hábitos alimenticios de *G. robusta* y *S. atromaculatus* con el objetivo de proveer información sobre la ecología de cada especie y obtener ideas con respecto a una posible superposición trófica entre ambas especies. *Gila robusta* y *S. atromaculatus* parecen ser generalistas y oportunistas que consumen una diversidad de alimentos. Material vegetal, insectos acuáticos y terrestres, y peces dominaron los contenidos estomacales de ambas especies, aunque gasterópodos y moluscos también fueron detectados. Los contenidos estomacales de ambas especies fueron similares, lo que indica una alta superposición trófica. Ningún patrón en dieta relacionado con longitud fue observado en estas dos especies. Los resultados de esta investigación sugieren que *S. atromaculatus* tiene el potencial de afectar negativamente a *G. robusta* a través de una competencia por alimentos y al grupo de peces nativos a través de la depredación.

Native fishes of the Upper Colorado River Basin (UCRB) have experienced substantial declines over the last 100 y (Minckley and Deacon, 1991; Tyus and Saunders, 2000). Several native species receive federal protection (e.g., endangered bonytail, *Gila elegans*; Colorado pikeminnow, *Ptychocheilus lucius*; and razorback sucker, *Xyrauchen texanus*), and many others are listed by various state and tribal agencies (Tyus and Saunders, 2000; Bezzerides and Bestgen, 2002). Though not federally protected under the Endangered Species Act, the roundtail chub, *Gila robusta*, has experienced dramatic declines in distribution and abundance across its native range. Bezzerides and Bestgen (2002) estimated that roundtail chub occupy approximately 55% of their historical UCRB habitats. Mechanisms responsible for the decline of roundtail chub and other native fishes in the UCRB are complex and include the effects of water development, habitat degradation, and interactions with nonnative species (Minckley and Deacon, 1991; Tyus and Saunders, 2000; Minckley et al., 2003).

The native fish assemblage in the Colorado River drainage of Wyoming includes 11 species (Baxter and Stone, 1995). Razorback sucker, bonytail, and Colorado pikeminnow probably have been extirpated, and bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*C. latipinnis*), and roundtail chub are rare in Wyoming (Baxter and Stone, 1995). Roundtail chub is considered imperiled by the Wyoming Natural Diversity Database and sensitive by the United States Bureau of Land Management. The Wyoming Game and Fish Department identifies roundtail chub as experiencing ongoing, significant losses of habitat, with populations that are greatly restricted or declining, with the possibility of extinction (Miller and Weitzel, 2003).

Muddy Creek, a cold-desert steppe stream in south-central Wyoming, is a tributary to the Little Snake River and is the only known area in Wyoming with sympatric populations of roundtail chub, bluehead sucker, and flannelmouth sucker. The Muddy Creek watershed is approximately 2,500 km^2 and ranges in elevation from 1,900 to 2,500 m above sea level. Historically, downstream reaches of Muddy Creek were dominated by native warmwater species (e.g., roundtail chub, bluehead sucker, flannelmouth sucker), but creek chub (*Semotilus atromaculatus*) and white sucker (*Catostomus commersoni*) have invaded lower reaches. The effects of creek chub and white sucker on native warmwater species in Muddy Creek are not well understood. The likely effect of white sucker on native species is through competitive interactions and hybridization with native suckers (Bezzerides and Bestgen, 2002). Creek chub is native to the eastern USA and might compete with roundtail chub or prey on native fishes (e.g., Dinsmore, 1962; Barber and Minckley, 1971). Creek chub is of particular concern given that nonnative predators are a major factor influencing native fishes in the Colorado River basin (Bestgen and Propst, 1989). Despite the current status of roundtail chub throughout its native distribution, roundtail chub is one of the least-studied and least-understood species in the UCRB (Bezzerides and Bestgen, 2002), particularly in Wyoming, where little is known about their ecology. Therefore, this study was conducted to 1) describe the summer food habits of roundtail chub and creek chub, 2) determine if there is trophic overlap between the 2 species, and 3) determine if creek chub prey on native fishes in Muddy Creek.

Methods—Roundtail chub and creek chub were collected from Muddy Creek approximately 70 km upstream from its confluence with the Little Snake River during July 2004 using a backpack electrofishing unit (Smith Root, Model 12-B, Vancouver, Washington). Our sampling was limited to the collection of 50 fish of each species due to the rarity and status of roundtail chub. However, we attempted to collect at least 10 fish per 5-cm length group to account for potential variation in diet due to fish length. Collected fish were immediately euthanized and total length (TL) was measured to the nearest millimeter. The entire digestive tract was removed from each fish by cutting at the junctions of the esophagus and the vent, and then fixed in 10% formalin (Bowen, 1996).

We identified prey items in stomachs to the lowest possible taxonomic level (generally order or family) using keys by Eddy and Underhill (1978), Pennak (1978), Merritt and Cummins (1984), and Sublette et al. (1990). Prey items in stomachs were counted and weighed to the nearest 0.001 g. Prey items in intestines also were examined, but digestion limited our analysis to a description of presence or absence of prey taxa.

Stomach contents of roundtail chub and creek chub were summarized using frequency of occurrence (100 × number of fish with prey taxa *i*/total number of fish), percent occurrence by number (100 × number of prey taxa *i*/total number of prey items), and percent occurrence by weight (100 × weight of prey taxa *i*/total weight of prey items) (Bowen, 1996). Percent by number and percent by weight were determined for each individual and averaged to obtain an estimate of the relative importance of each prey taxon in the diet. Length-related patterns in prey consumption were examined by plotting percent by number or percent by weight of each prey taxon against fish length. Linear-regression analysis also was used to examine length-related trends by regressing percent by number and percent by weight of each prey taxon against fish length. The magnitude of trophic overlap between roundtail chub and creek chub was evaluated using Schoener's index of trophic overlap: $C_{xy} = 1 - 0.5(\Sigma |p_{xi} - p_{yi}|)$, where C_{xy} is the index value, p_{xi} is the proportion of prey i used by species x, and p_{yi} is the proportion of prey i used by species y (Schoener, 1971; Crowder, 1990; Bowen, 1996). Index values were calculated using percent by number and percent by weight.

RESULTS—Roundtail chubs ranged from 90 to 259 mm TL (mean ± *SE*: 164.1 ± 7.5 mm; $n = 50$) and creek chubs ranged from 70 to 175 mm TL (132.0 ± 3.8 mm; $n = 50$). Empty stomachs were observed for 34% of the roundtail chubs and 28% of the creek chubs. Results of regression analyses (roundtail chub, $r^2 =$ 0.01 to 0.16 and $P =$ 0.06 to 0.96 among species; creek chub, $r^2 =$ 0.01 to 0.12 and $P =$ 0.03 to 0.99 among species) and examination of bivariate plots did not indicate length-related trends. The most common items in roundtail chub stomachs were detritus (i.e., plant material), aquatic and terrestrial insects, and fishes (Table 1). Although we were unable to identify many prey items due to mastication and digestion, a large portion of the identifiable insects were of terrestrial origin (44%). We were unable to identify the fish species consumed by roundtail chub, except for a creek chub consumed by a 259 mm TL roundtail chub. Piscivorous roundtail chubs were 95 to 259 mm TL. In addition, mussels (Veneroida) were found in the stomachs of roundtail chubs. The only prey items found in the intestines and not in the stomach were leptocerids (Trichoptera).

The most common prey items observed in creek chub stomachs were terrestrial and aquatic insects, followed by detritus and fishes (Table 1). Similar to roundtail chub, a large portion of the identifiable insects were of terrestrial origin (43%). Piscivorous creek chubs were 144 to 175 mm TL. We were unable to identify the species of most fishes consumed, but we identified one creek chub (consumed by a 144 mm TL fish) and one bluehead sucker (consumed by a 175 mm TL fish). Leptocerids were the only prey items observed in creek chub intestines that were not found in stomachs.

Detritus and unidentified insects were the most frequent (by number and weight) prey of roundtail chub (Table 1), but fishes were also important in the diet and averaged 12% of both the number and weight of all prey in stomachs. Among identifiable insects, brachycentrids were relatively important in the diet of roundtail chub, but were not extremely common. Additional prey taxa of high importance to roundtail chub included aquatic insects, such as larval Diptera, Trichoptera, and Siphlonuridae, and terrestrial invertebrates, such as ants (Formicidae) and grasshoppers (Acrididae).

Insects and plant material were the most frequent (by number and weight) prey items in creek chub stomachs (Table 1). The next most frequent prey items with respect to number were ants, larval Gomphidae, and fishes. These same prey items were most frequent with regard to weight, but the order of importance was larval Gomphidae, fishes, and ants. Additional prey taxa important in creek chub diets included mussels, larval Trichoptera (Limnephilidae and unidentified Trichoptera), and larval and adult Hymenoptera (adult Ichneumonidae and unidentified Hymenoptera).

Overall diet composition was similar between roundtail chub and creek chub. Schoener index values were 0.97 (using percent by number) and 0.98 (using percent by weight), suggesting a high degree of overlap between the 2 species.

DISCUSSION—Competition with nonnative species is considered one of the most important factors influencing the conservation of native fishes in the UCRB (Tyus and Saunders, 2000; Bezzerides and Bestgen, 2002; Minckley et al., 2003). Our results and published studies (e.g., Moshenko and Gee, 1973; Copes, 1978; Tyus and Minckley, 1988; Rinne, 1992) suggest that both roundtail chub and creek chub are opportunistic generalists that feed on a variety of prey items. In addition, we observed high trophic overlap between roundtail chub and creek chub in Muddy Creek. Our study was conducted over a relatively short period of the summer, but summer is often considered a critical period affecting fishes, particularly in desert stream systems (e.g., Minckley and Deacon, 1991; Magoulick and Kobza, 2003). Consequently, competitive interactions between roundtail chub and creek chub might be important in Muddy Creek and other areas of the UCRB. Additional field studies conducted over

TABLE 1—Frequency of occurrence (%O), frequency by number (%N), and frequency by weight (%W) of prey items in stomachs of roundtail chub (*Gila robusta*, RTC; n = 33) and creek chub (*Semotilus atromaculatus*, CKC; n = 36) with food items in the Muddy Creek watershed, Wyoming, July 2004. Numbers in parentheses represent 1 *SE*.

	%O		%N		%W	
Prey taxa	RTC	CKC	RTC	CKC	RTC	CKC
Arachnida						
Unidentified Araneae	0.0	2.8	0 (0)	0.7 (0.7)	0 (0)	1.4 (1.4)
Insecta						
Unidentified Insecta	24.2	22.2	23.6 (7.8)	20.1 (6.2)	23.3 (8.4)	21.1 (6.4)
Hemiptera						
Unidentified Hemiptera	0.0	2.8	0 (0)	2.7 (2.7)	0 (0)	2.7 (2.7)
Naucoridae	0.0	5.6	0 (0)	2.3 (1.6)	0 (0)	1.0 (0.8)
Hymenoptera						
Unidentified Hymenoptera	0.0	2.8	0 (0)	2.7 (2.7)	0 (0)	2.7 (2.7)
Formicidae	3.0	13.9	4.2 (4.2)	10.4 (4.5)	4.2 (4.2)	7.6 (3.9)
Ichneumonidae	0.0	2.8	0 (0)	2.7 (2.7)	0 (0)	2.7 (2.7)
Ephemeroptera						
Siphlonuridae	3.0	0.0	3.7 (3.7)	0 (0)	0.2 (0.2)	0 (0)
Odonata						
Unidentified Odonata	3.0	8.3	1.4 (1.4)	0 (0)	0.6 (0.6)	0 (0)
Gomphidae	0.0	13.9	0 (0)	9.7 (4.3)	0 (0)	9.6 (4.5)
Trichoptera						
Unidentified Trichoptera	3.0	5.6	4.2 (4.2)	1.8 (1.3)	4.2 (4.2)	2.7 (1.8)
Brachycentridae	6.0	0.0	6.3 (4.5)	0 (0)	6.3 (4.5)	0 (0)
Limnephilidae	0.0	8.3	0 (0)	5.4 (3.2)	0 (0)	4.7 (3.0)
Coleoptera						
Unidentified Coleoptera	0.0	2.8	0 (0)	1.8 (1.3)	0 (0)	1.6 (1.3)
Coccinellidae	3.0	2.8	0 (0)	0.9 (0.9)	0 (0)	2.2 (2.2)
Dryopidae	3.0	0.0	0 (0)	2.7 (2.7)	0 (0)	2.7 (2.7)
Elmidae	0.0	5.6	2.8 (2.8)	0 (0)	0.4 (0.4)	0 (0)
Diptera						
Unidentified Diptera	3.0	2.8	4.2 (4.2)	0.9 (0.9)	4.2 (4.2)	1.0 (1.0)
Chironomidae	3.0	0.0	0.7 (0.7)	0 (0)	0.2 (0.2)	0 (0)
Orthoptera						
Unidentified Orthoptera	3.0	0.0	1.4 (1.4)	0 (0)	3.8 (3.8)	0 (0)
Acrididae	3.0	2.8	4.2 (4.2)	0.7 (0.7)	4.2 (4.2)	1.4 (1.4)
Gastropoda						
Unidentified Gastropoda	0.0	8.3	0 (0)	4.0 (2.2)	0 (0)	3.2 (1.9)
Bivalvia						
Veneroida	3.0	8.3	1.4 (1.4)	6.8 (3.9)	0.2 (0.2)	6.2 (3.8)
Osteichthyes						
Cypriniformes						
Unidentified Cypriniformes	12.1	11.1	11.8 (6.0)	6.3 (3.3)	11.7 (6.4)	7.7 (4.3)
Bluehead sucker	0.0	2.8	0 (0)	1.4 (1.4)	0 (0)	1.6 (1.6)
Creek chub	3.0	2.8	4.2 (4.2)	1.4 (1.4)	4.2 (4.2)	2.2 (2.2)
Detritus	24.2	22.2	26.2 (8.9)	12.8 (4.5)	32.5 (9.6)	14.4 (5.1)

a longer temporal scale and detailed experimental studies are needed to better understand potential competitive interactions.

Another mechanism by which nonnative species might influence native species is by predation (Taylor et al., 1984; Minckley et al., 2003). We found that creek chub preyed on at least one native species (i.e., bluehead sucker). Most (>90%) of the unidentified fishes were either creek chub or roundtail chub, but given that both species have a 2,5–4,2 pharyngeal tooth count (Sublette et al., 1990), we were unable to accurately identify the species when only pharyngeal teeth were present. Similarly, pharyngeal tooth counts for suckers (other than bluehead sucker) were inconclusive given similar tooth counts for white sucker and flannelmouth sucker (Sublette et al., 1990). Because unidentified fishes were one of the most important prey items for roundtail chub, predation by roundtail chub might be as high or greater than by creek chub. Regardless, creek chubs consumed bluehead suckers, suggesting that they might adversely influence native species.

Roundtail chub in Muddy Creek had a diverse diet of aquatic and terrestrial insects, mollusks, and fishes. Previous studies have shown that small, juvenile roundtail chubs consume a variety of prey items, including larval Diptera, Ephemeroptera, Trichoptera, and algae (Neve, 1976; Bestgen, 1985). Large juvenile and adult roundtail chubs generally have a more diverse diet of terrestrial and aquatic insects, fish, plant matter, crustaceans, and reptiles (Koster, 1957; Vanicek and Kramer, 1969; Schreiber and Minckley, 1981; Tyus and Minckley, 1988; Karp and Tyus, 1990; Rinne, 1992). In Muddy Creek, plant material was common in stomachs of roundtail chub. Plant material might be consumed as an artifact of preying on aquatic macroinvertebrates or epiphytic prey (e.g., Bestgen, 1985). Numerous studies have shown that consumption of algae and other plant material increases with reductions in invertebrate biomass (e.g., due to flooding), suggesting that ingestion of plant material might be purposeful (Neve, 1976; Schreiber and Minckley, 1981; Bestgen, 1985).

Creek chub in Muddy Creek also consumed a diverse array of prey items. Although creek chub is a nonnative species in the system, its diet was similar to areas in which it is native. For instance, Dinsmore (1962) described the food habits of creek chub in the Des Moines River, Iowa, and found that they consumed a diversity of aquatic and terrestrial insects, fish, and mollusks, and that plant material was one of the most frequent items during summer. Similarly, Barber and Minckley (1971) found that the summer food habits of creek chub in the Mississippi River, Minnesota, consisted of aquatic and terrestrial insects, mollusks, and fish. Other studies across the distribution of creek chub have shown its diverse diet (e.g., Moshenko and Gee, 1973; Copes, 1978).

Our study was limited to the Muddy Creek drainage of Wyoming and focused on the summer period, but it provides important information on the trophic ecology of roundtail chub and creek chub in the UCRB. Little is known about the ecology of roundtail chub or the ecology of creek chub in areas where it has been introduced. In Wyoming, the lack of information is particularly apparent and Muddy Creek might harbor one of the last remaining lotic populations of roundtail chub in the state. Therefore, information on roundtail chub and their interaction with nonnative species is important for their conservation in Wyoming and the UCRB. Our results suggest that both roundtail chub and creek chub are trophic generalists that feed on a diverse array of prey taxa. Our results also suggest high trophic overlap between the 2 species and that creek chub consume native fishes. Future research should focus on the specific effects of creek chub on native fishes to help guide conservation and management activities in the basin. Potential avenues for research include investigating early life history interactions and examining season-specific competitive interactions and predation.

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Literature Cited

Barber, W. E., and W. L. Minckley. 1971. Summer foods of the cyprinid fish *Semotilus atromaculatus*. Transactions of the American Fisheries Society 100:283–289.

Baxter, G. T., and M. D. Stone. 1995. Fishes of Wyoming. Wyoming Game and Fish Department, Cheyenne.

Bestgen, K. R. 1985. Distribution, biology and status of the roundtail chub, *Gila robusta*, in the Gila River basin, New Mexico. Unpublished M.S. thesis, Colorado State University, Fort Collins.

Bestgen, K. R., and D. L. Propst. 1989. Distribution, status, and notes on the ecology of *Gila robusta* (Cyprinidae) in the Gila River drainage, New Mexico. Southwestern Naturalist 34:402–412.

Bezzerides, N., and K. R. Bestgen. 2002. Status review of roundtail chub *Gila robusta*, flannelmouth sucker *Catostomus latipinnis*, and bluehead sucker *Catostomus discobolus* in the Colorado River basin. Larval Fish Laboratory Contribution 118, Colorado State University, Fort Collins.

Bowen, S. H. 1996. Quantitative description of the diet. In: B. R. Murphy and D. W Willis, editors. Fisheries techniques, second edition. American Fisheries Society, Bethesda, Maryland. Pages 513–532.

Copes, F. A. 1978. Ecology of the creek chub. University of Wisconsin Museum of Natural History, Report on the Fauna and Flora of Wisconsin Number 12, Stevens Point.

Crowder, L. B. 1990. Community ecology. In: C. B. Schreck and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland. Pages 609–632.

Dinsmore, J. J. 1962. Life history of the creek chub. Proceedings of the Iowa Academy of Science 69: 296–301.

Eddy, S., and J. C. Underhill. 1978. How to know the freshwater fishes, third edition. Wm. C. Brown Company, Publishers, Dubuque, Iowa.

Karp, C. A., and H. M. Tyus. 1990. Humpback chub (*Gila cypha*) in the Yampa and Green rivers, Dinosaur National Monument, with observations on roundtail chub (*Gila robusta*) and other sympatric fishes. Great Basin Naturalist 50:257–264.

Koster, W. J. 1957. Guide to the fishes of New Mexico. University of New Mexico Press, Albuquerque.

Magoulick, D. D., and R. M. Kobza. 2003. The role of refugia for fishes during drought: a review and synthesis. Freshwater Biology 48:1186–1198.

Merritt, R. W., and K. W. Cummins. 1984. An introduction to the aquatic insects of North America, second edition. Kendall-Hunt Publishing Company, Dubuque, Iowa.

Miller, D. D., and D. L. Weitzel. 2003. Management considerations for native non-game fishes of Wyoming. Wyoming Game and Fish Department, Native Non-Game Fishes Conservation Assessment NDSWLB3510, Cheyenne.

Minckley, W. L., and J. E. Deacon, editors. 1991. Battle against extinction: native fish management in the American West. University of Arizona Press, Tucson.

Minckley, W. L., P. C. Marsh, J. E. Deacon, T. E. Dowling, P. W. Hedrick, W. J. Matthews, and G. Mueller. 2003. A conservation plan for native fishes of the lower Colorado River. BioScience 53: 219–234.

Moshenko, R. W., and J. H. Gee. 1973. Diet, time and place of spawning, and environments occupied by creek chub (*Semotilus atromaculatus*) in the Mink River, Manitoba. Journal of the Fisheries Research Board of Canada 30:357–362.

Neve, L. L. 1976. The life history of the roundtail chub, *Gila robusta grahami*, at Fossil Creek, Arizona. Unpublished M.S. thesis, Northern Arizona University, Flagstaff.

Pennak, R. W. 1978. Freshwater invertebrates of the United States. John Wiley and Sons, Inc., New York.

Rinne, J. N. 1992. Physical habitat utilization of fish in a Sonoran Desert stream, Arizona, southwestern United States. Ecology of Freshwater Fish 1: 35–41.

Schoener, T. W. 1971. Theory of feeding strategies. Annual Review of Ecology and Systematics 2:369–404.

Schreiber, D. C., and W. L. Minckley. 1981. Feeding interrelations of native fishes in a Sonoran Desert stream. Great Basin Naturalist 41:409–426.

Sublette, J. E., M. D. Hatch, and M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque.

Taylor, J. R., W. R. Courtenay, and J. A. McCann. 1984. Known impacts of exotic fish introductions in the continental United States. In: W. R. Courtenay and J. R. Stauffer, editors. Distribution, biology, and management of exotic fishes. John Hopkins University Press, Baltimore, Maryland. Pages 322–373.

Tyus, H. M., and W. L. Minckley. 1988. Migrating Mormon crickets, *Anabrus simplex* (Orthoptera: Tettigoniidae), as food for stream fishes. Great Basin Naturalist 48:25–30.

Tyus, H. M., and J. F. Saunders, III. 2000. Nonnative fish control and endangered fish recovery: lessons from the Colorado River. Fisheries 25(9): 17–24.

Vanicek, C. D., and R. H. Kramer. 1969. Life history of the Colorado squawfish, *Ptychocheilus lucius*, and the Colorado chub, *Gila robusta*, in the Green River in Dinosaur National Monument, 1964–1966. Transactions of the American Fisheries Society 98:193–208.

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