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D. B. McCarraher
Nebraska Game, Forestation and Parks Commission

Robert Thomas
Nebraska Game, Forestation and Parks Commission

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INTRODUCTION

Populations of the fathead minnow, *Pimephales promelas*, were apparently common throughout the sandhills region of Nebraska, prior to the appearance of the first pioneers, for Aughey (1880) listed the species as part of the native fauna. Current data relating to the distribution (Figure 1) and gross ecology of the species throughout the sandhills, was first collected in 1954 by the authors, with continuous observances recorded since that year. The fathead minnow is a common species throughout the northern great plains and appears to reach its greatest abundance in the shallow, alkaline lakes of Nebraska. Our investigations over the past ten years indicates that the species is found in about 240 sandhill lakes with population densities variable according to alkalinity content of the lake. Only one monographic report by Izaak (1961) reflects on the life history of the minnow in North America. Adequate information is not available indicating water quality parameters. It is the intent of this paper to describe some of the ecological characteristics that reflect the life history of the fathead minnow in the alkaline sandhill lakes of Nebraska.

ABUNDANCE AND DISTRIBUTION

Field observations clearly demonstrate that the abundance of the fathead minnow closely follows seasonal changes in individual lake water quality (Tables 1 and 2). Populations in Smithys Lake flourish during the spring months when carbonate alkalinity remains below 800 ppm and the total alkalinity does not exceed 1,800 ppm. Chemical conditions in excess of these values appear to greatly impair the reproduction and abundance of the minnow.

In East Twin Lake, the annual water quality varies drastically from year to year causing a complete disappearance of the minnow during years of high alkalinity values. The senior author first recorded the fathead minnow population and water chemistry in East Twin Lake

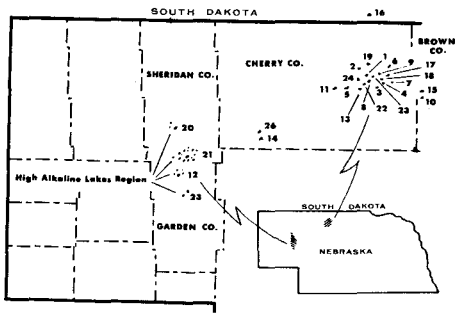

FIGURE 1. Fathead Minnow Study Lakes (Numbers refer to Tables 1 and 2).

during 1959 when the total alkalinity values were between 875–940 ppm. By 1961 when the water level receded and the resultant total alkalinity readings reached 3,575 ppm the fathead minnow population in East Twin Lake disappeared. Increased water level and decreased alkalinity below 2,000 ppm brought about the re-establishment of the fathead minnows by late 1962. It is believed that repopulation was established by migrating shorebirds and waterfowl transporting viable fish eggs adhering to external surfaces of the birds.

Abundance and distribution are probably regulated, to a lesser extent, by interspecific competition from other fish species. Intraspecifc activity versus populated density was not evaluated during this study.

In Horseshoe Lake, Minnesota, the resident fish population of fivespine stickleback, *Culaca inconstans* (Kirtland); mud minnow, *Umbra limi* (Kirtland); and the black bullhead, *Ictalurus melas* (Raf.), did not appear to interfere with the normal activities of the fathead minnow (Izaak, 1961).

In Rodgers, Dads, Ell, Skull, and Mule Lakes of the Nebraska sandhills region black bullhead and green sunfish, *Lepomis cyanellus* (Rafinesque) are abundant and feed to some extent on the minnows.

During most winters a depletion of dissolved oxygen may occur in several of the shallower lakes, notably Rodgers, White, East Twin, and McKeel Pond #1. Dissolved oxygen content below 0.8 ppm greatly reduced the minnow population in these lakes. The mortality appeared to be greatest among the age 0 group.

Rawson and Moore (1944) noted fathead minnow survival in the Saskatchewan sulfate lakes having nearly 15,000 ppm total solids. These lakes differ chemically from the alkaline water conditions prevailng in Nebraska sites (Tables 1 and 2).

White Lake, South Dakota, located a few miles north of the Nebraska border has maintained a high population of fathead minnows for many years. The lake contains a higher proportion of sulfate and chloride ions than the Nebraska sandhill lakes and should be classified as a sodium-sulfate type (Table 1). Its total alkalinity ranges from 830 ppm (1960) to 2,600 ppm (1965) and fluctuates widely each year. The maximum total solids recorded was 3,862 ppm in March, 1965.

GROWTH

The male minnows often grow to large size in the higher alkaline lakes. Several specimens were collected from Smithys Lake during late summer having a total length of 90–101 mm. These minnow lengths exceed that reported by Carlander (1950). Izaak (1961) collected fish up to 69 mm total length during the late fall months while Markus (1934) reared males up to the maximum size of 78 mm in small rearing ponds. All specimens were age 1 or less.

The growth rate of the sandhill populations appears to be influenced by water quality, food supply, and density of the population. Those alkaline lakes, where total alkalinity annually ranges between 800–1,800 ppm, have provided the largest specimens. These same alkaline lakes are characterized by high densities of zooplankton and phytoplankton populations. Winter dissolved oxygen depletion periodically removes a portion of the fathead minnow population thus alleviating crowding and consequently greatly reduces intraspecific competition.

REPRODUCTION

Fathead minnows have successfully spawned in alkaline lakes where the total alkalinity during the spring and early summer does not exceed 2,000 ppm. Spawning success appears to decline sharply above this value. Carbonate alkalinity was found to present toxic environmental conditions for natural recruitment above 850 ppm concentrations (Table 2).

TABLE 1.—*Physical and average chemical conditions of lakes in which fathead minnows have survived for six or more months*

Lake	Number[1]	Surface acres	Average depth (ft.)	CO_3	HCO_3	pH	Na	K	Ca	SO_4	Mg	Cl	Total hardness	Total solids
Rodgers	1	22	3.0	332	632	9.2	300	215	16	14	152	34	768	1,400
Hudson	2	130	4.5	260	464	9.1	350	300	43	60	22	30	200	1,546
McKeel	3	48	3.2	408	442	9.2	300	150	43	20	5	80	128	1,012
McKeel Pond #1	4	0.6	3.5	208	1492	9.4	450	250	40	60	9	100	136	2,118
Mule	5	348	4.8	78	385	8.8	—	—	82	12	20	72	102	540
East Twin	6	67	3.2	567	1378	9.4	655	500	22	43	11	143	100	2,323
Ell	7	120	3.8	148	420	9.2	267	189	26	7	23	29	160	1,000
By-Way	8	36	3.5	674	1305	9.5	475	330	46	6	16	120	62	2,197
Smithys #4	9	1	2.8	420	986	9.3	600	300	46	14	11	16	160	1,878
Skull	10	60	4.2	123	562	9.0	—	—	37	80	—	37	—	817
Stout	11	12	4.5	202	94	9.2	80	92	56	38	—	98	119	600
Bean	12	259	4.8	374	969	9.1	—	—	—	—	—	—	—	1,343
Dads	13	1025	5.6	88	248	9.3	130	95	14	6	4	21	52	594
South Twin	14	45	4.6	442	918	9.2	500	310	34	25	11	118	128	2,292
Skull #1	15	72	3.0	124	876	8.8	400	150	48	20	2	120	128	1,334
White, S.D.	16	230	3.2	466	903	9.1	435	187	33	620*	0.0	122	29	1,880
Average Chemical Conditions				307	754	9.1	380	236	36	29	23	76	162	1,429

* Not included in total average.
[1] For location of lakes see Figure 1.
— Not recorded.

In the Smithys Lake drainage system, where occasionally the alkaline content of the lake restricts reproduction, fathead minnows may ascend a drainage marsh where the water is considerably less alkaline. Where the total alkalinity is about 300 ppm the natural recruitment and their downstream movement from the marsh replenishes the minnow population of Smithys Lake.

Spawning commences about the third week of April when surface water temperatures reach 58–65 F. Fathead minnow eggs have been collected from fence posts, barb wire, and the stems of hardstem bulrush, *Scirpus americanus*. Although sago pondweed, *Potemogeton pectinatus*, and *Chara* sp., are the common submergent plants in the alkaline lakes few eggs have been collected from these plants. All egg deposits on fences and bulrush stems were encountered at depths of ±3 feet. These spawning depths closely parallel the findings by Izaak (1961).

In those sandhill lakes where fathead minnows are especially abundant the populations have coelomic cavity infestations of the cestoda, *Ligula intestinalis*. This parasite appears to greatly restrict the reproductive potential of the host with female hosts containing about 42% fewer eggs than noninfected hosts. This percentage is based on the examination of ovaries from 182 infected fish from White and Rodgers lakes and 62 noninfected fish from other lakes.

Of the 290 adult minnows of both sexes

TABLE 2.—*Average physical and chemical conditions of sandhill lakes where fathead minnows survive six months or less*

Lake	Number[1]	Surface acres	Average depth (ft.)	CO_3	HCO_3	pH	Na	K	Ca	SO_4	Mg	Cl	Total hardness	Total solids	Survival period[2] (days)
Smithys #1	17	1.0	1.5	655	2215	9.7	2100	850	0.0	180	18	68	14	3590	30–38
Smithys #2	18	1.2	1.8	760	1778	9.8	2000	900	0.0	162	10	56	8	5390	36–45
Little Alkali	19	38	4.0	987	1951	9.8	728	775	16	101	206	155	35	3450	10–13
Diamond	20	318	4.2	842	1610	9.5	722	822	17	251	30	194	209	3440	8–12
Lakeside	21	85	3.2	5060	15700	10.1	7000	10872	0.0	1540	1	1600	—	27708	4–12 hrs.
McKeel #2	22	0.5	2.5	782	904	9.2	1100	1200	59	40	1	140	152	4358	80–84
Goose	23	364	4.0	610	2060	9.7	780	550	60	140	12	300	140	3710	70–94
School	24	84	4.2	680	731	9.4	1000	550	21	60	1	100	56	3248	60–80
Smithys	25	40	4.0	720	2580	9.6	1200	800	51	38	8	180	160	4650	60–135
North Twain	26	74	4.2	316	1884	9.6	750	250	35	40	6	100	112	2388	Not known
Average Chemical Conditions				1141	3141	9.6	1738	1756	26	255	29	239	105	6193	

[1] For location of lakes see Figure 1.
[2] Age O & I fathead minnows were placed in live cages and set in various depths in the lakes. Survival period reflects approximated number of days when first mortality appeared and total mortality of test fish in individual cages.
— Not recorded.

examined from Rodgers Lake, 88% contained one or more *Ligula intestinalis*. The incidence of infestation (79%) was also high in the White Lake populations. The number of *Ligula intestinalis* per infected minnow ranged from 1 to 22 with no direct relationship between the total length of the host and the total number of parasitic cestoda present.

In contrast to the heavy incidence of *Ligula intestinalis* found in several sandhill lakes, Izaak (1961) found this parasite in only 0.03% of the coelomic cavities of specimens from Horseshoe Lake.

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LITERATURE CITED

AUGHEY, SAMMUEL. 1880. Sketches of the physical geography and geology of Nebraska. Daily Republican Book and Job Office. Omaha. pp. 129–130.

CARLANDER, K. D. 1950. Handbook of Freshwater Fishery Biology. Wm. C. Brown Co., 281 p.

IZAAK, DANIEL. 1961. The ecological life history of the fathead minnow, *Pimephales promelas* (Rafinesque). Ph.D. thesis. Univ. Minnesota.

MARKUS, HENRY C. 1934. Life history of the blackhead minnow, *Pimephales promelas*. Copeia 1934 (3): 116–122.

RAWSON, D. S., AND J. E. MOORE. 1944. The saline lakes of Saskatchewan. Can. Res. 22: 141–201 p.

TRAUTMAN, MILTON B. 1957. The fishes of Ohio. Ohio State Univ. Press. 683 p.

D. B. MCCARRAHER

Nebraska Game, Forestation and Parks Commission
Hastings College
Hastings, Nebraska

ROBERT THOMAS

Nebraska Game, Forestation and Parks Commission
Lincoln, Nebraska