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COMMON CARP (*CYPRINUS CARPIO*) POPULATION CHARACTERISTICS AND RECRUITMENT IN TWO NEBRASKA SANDHILL LAKES

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ABSTRACT

Common carp (*Cyprinus carpio*) are a non-native fish in the United States. Due to their prolific nature, they may have detrimental effects on fish and waterfowl communities, including those of Nebraska Sandhill lakes. Information regarding population structure, age, and growth of common carp in Nebraska Sandhill lakes is lacking. We examined adult common carp populations from Marsh and Pelican lakes on the Valentine National Wildlife Refuge. We described size and age structure, growth, and recruitment patterns for these two populations. Age-frequency histograms revealed consistent recruitment of common carp through age 7 in Marsh Lake but inconsistent recruitment in Pelican Lake. Common carp growth was initially faster in Pelican Lake than in Marsh Lake, likely because of a less dense carp population in Pelican Lake. Pelican Lake contains northern pike (*Esox lucius*) and largemouth bass (*Micropterus salmoides*), top-level piscivores, while Marsh Lake contains no predatory fish species. The absence of top-level piscivores preying on age-0 common carp may have led to the denser population in Marsh Lake. Further research is recommended to understand fully the role of common carp in Sandhill lake communities.

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Common carp (*Cyprinus carpio*) have been introduced into many water bodies throughout the world, including Europe, Australia, and North America (Vooren 1972, Shearer and Mulley 1978, Mills et al. 1993). The wide distribution and successful introductions of common carp are largely due to their tolerance of varying environmental conditions (Forester and Lawrence 1978). Their ability to thrive in new water bodies has caused many ecosystem management problems. Common carp can affect the abiotic aspects of aquatic communities substantially. For example, common carp have been shown to increase turbidity, total phosphorus, and ammonia concentrations (Lougheed et al. 1998, Angeler et al. 2002). Also, high population abundances have been positively correlated with increases in chlorophyll *a* levels, increased nitrogen concentrations, and an increased amount of suspended solids (Angeler et al. 2002, Parkos et al. 2003).

Common carp can also have detrimental effects on the biotic potential of aquatic ecosystems directly and indirectly through their feeding and spawning habits (Zambrano and Hinojosa 1999). Common carp can reduce abundances of submerged macrophytes and macroinvertebrates (Crivelli 1983, Parkos et al. 2003). As a result, common carp can thus affect the abundance of recreational fish species and waterfowl that depend on macrophytes and macroinvertebrates

for food and cover at various life stages (Forester and Lawrence 1978).

Because common carp can have substantial impacts on aquatic ecosystems, understanding basic population characteristics is a necessary first step to determine appropriate management strategies. This information, however, is lacking for populations in Nebraska Sandhill lakes. Therefore, our objective was to describe the size and age structure, growth, and recruitment patterns of common carp in Marsh and Pelican lakes, Nebraska.

STUDY SITES

Marsh Lake and Pelican Lake are located in Cherry County, Nebraska, on the Valentine National Wildlife Refuge. Marsh Lake has a surface area of 907 ha, and mean and maximum depths of 1.8 m and 2.6 m. Pelican Lake covers 332 ha, and has mean and maximum depths of 1.2 m and 1.9 m (Paukert and Willis 2000). Marsh Lake had lower aquatic macrophyte coverage (14% coverage of emergent and submergent vegetation), while Pelican Lake had moderate aquatic macrophyte coverage (37% total coverage; Paukert and Willis 2000). Both fish communities were simple but quite different -- Marsh Lake contained no top-level piscivores while Pelican Lake did. In addition to common carp, Marsh Lake primarily contained black bullhead (*Ameiurus melas*), golden shiner (*Notemigonus crysoleucas*), and yellow perch (*Perca flavescens*). Pelican Lake contained northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), yellow perch, bluegill (*Lepomis macrochirus*), and black bullhead.

METHODS

Common carp were sampled from Marsh Lake in April of 2006 using modified fyke nets (16-mm bar mesh, 1.1- by 1.5-m frames, and 22-m leads), while carp in Pelican Lake were collected with pulsed-DC (200-250 V, 3-6 A) boat electrofishing in July of 2006. Total length (mm) and weight (g) were recorded, and length-frequency histograms were generated to describe common carp population size structure in each lake. We then calculated proportional stock density (PSD; percentage of 28-cm and longer fish that also exceeded 41 cm) and relative stock density of preferred-length fish (RSD-P; the percentage of 28-cm and longer fish that also exceeded 53 cm) to quantify size structure (Gabelhouse 1984). The 95% confidence intervals (CI) for PSD and RSD-P were calculated as suggested by Gustafson (1988). Catch per unit effort (CPUE), an index of population abundance, was calculated as the mean number of fish $\geq$ stock length (i.e., 28 cm) captured per net night or per hour of electrofishing (Hubert 1996).

Asteriscus otoliths, the only validated aging structure for common carp (Brown et al. 2004), were removed from common carp to determine age and growth. Otoliths were mounted in epoxy and sectioned transversely through the nucleus using a low-speed Isomet saw. Two independent readers determined age in years with the aid of a microscope. Discrepancies in age assignments were resolved by examining the otoliths in unison. Age-frequency histograms were created to describe the age structure and assess recruitment patterns in both lakes. Growth was described as mean length by cohort at time of capture and von Bertalanffy growth parameters were determined for each population (Van Den Avyle and Hayward 1999).

Reproductive status and sex of pre-spawn common carp from Marsh Lake was recorded by determining sexual maturity through direct examination of gonads. We determined 50% maturity at length and age using probit analysis (Welch and Foucher 1988). Reproductive characteristics were not recorded from carp from Pelican Lake because they were sampled post-spawn (i.e., July).

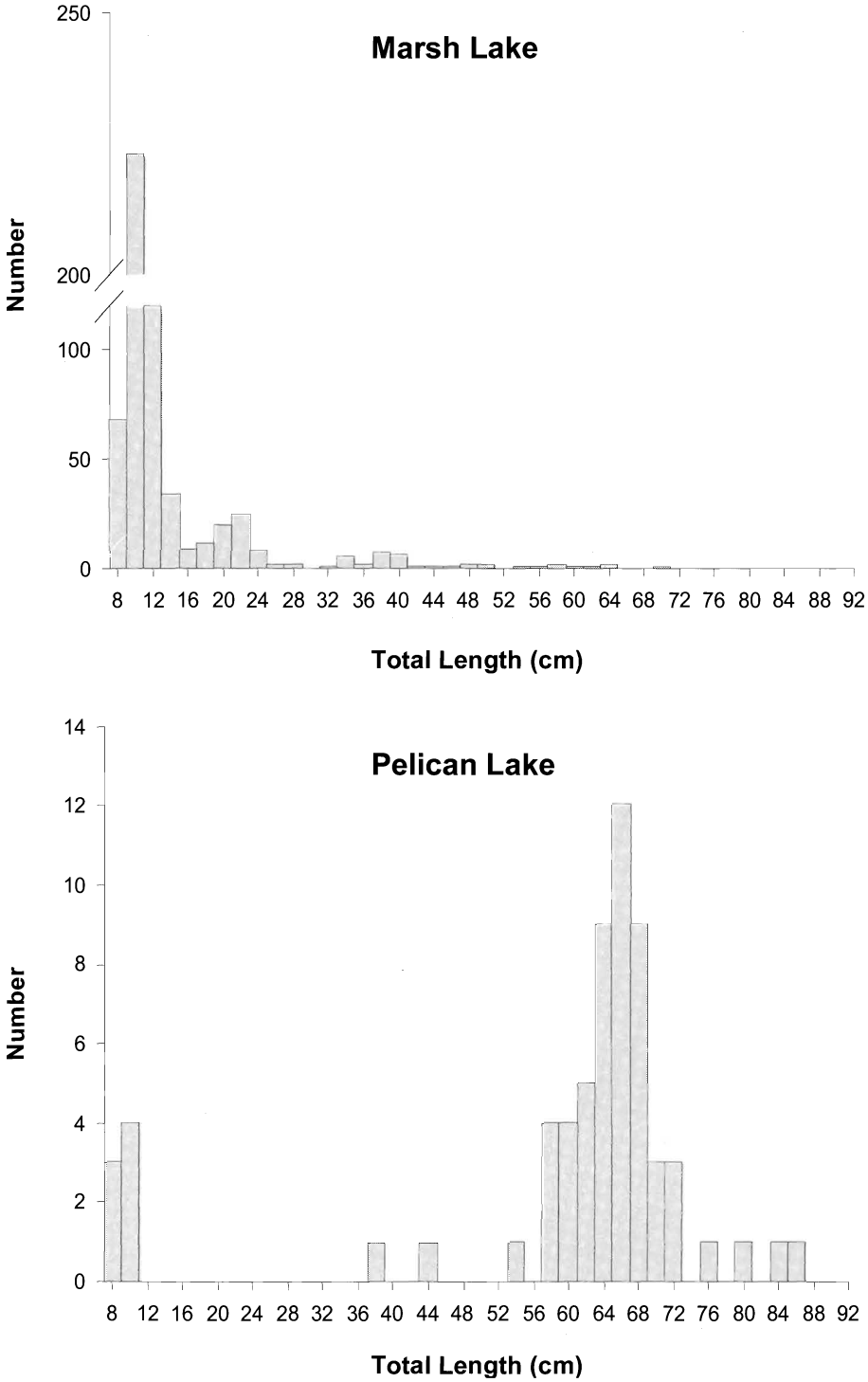

Figure 1. Length frequency by 2-cm length groups for common carp sampled from Marsh and Pelican lakes, Nebraska in April and July of 2006, respectively.

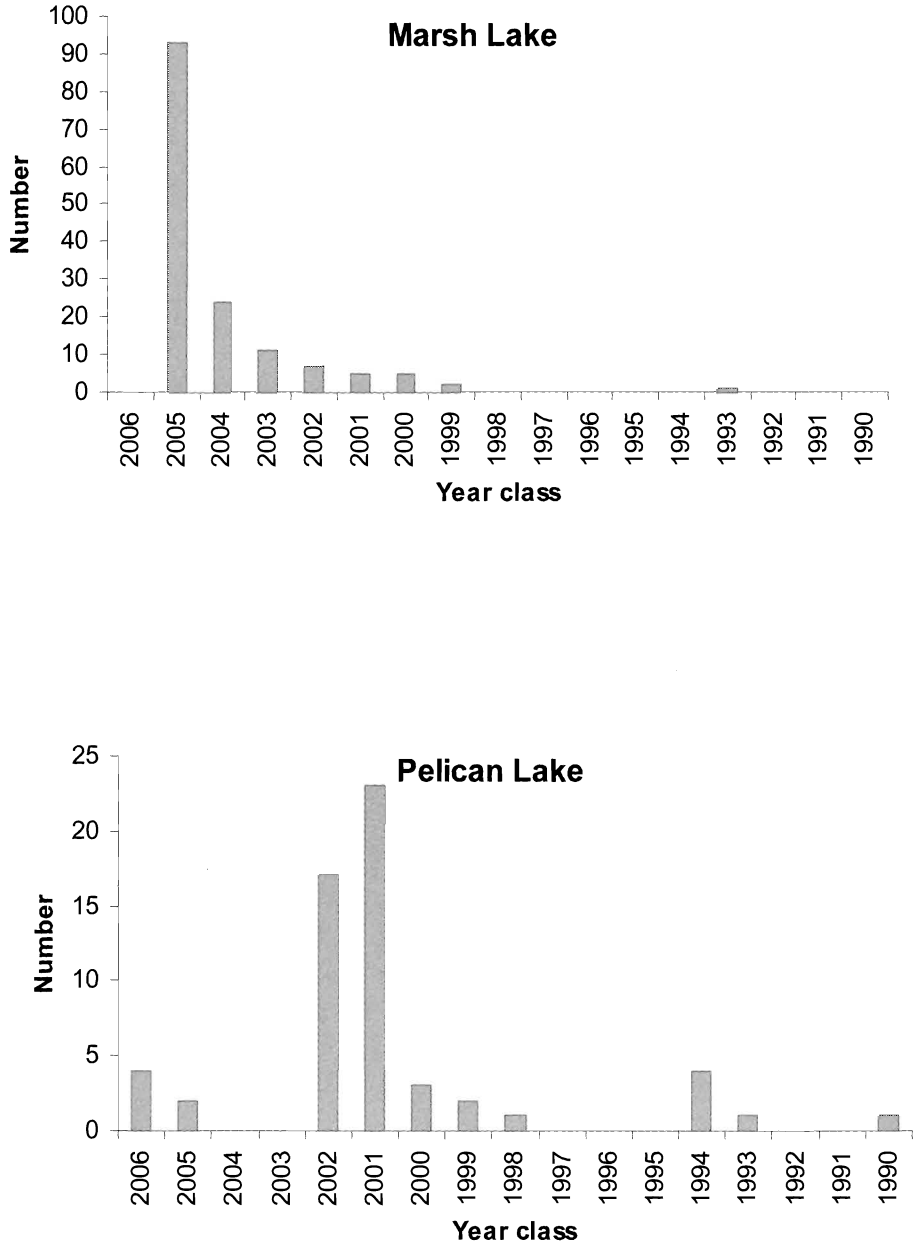

Figure 2. Age frequency for common carp sampled from Marsh and Pelican lakes, Nebraska in April and July of 2006, respectively.

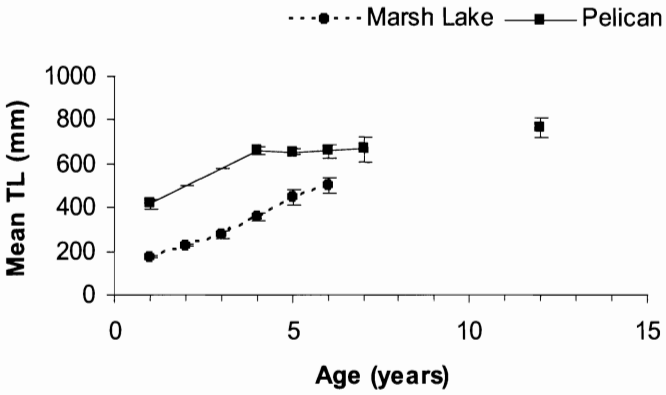

Figure 3. Mean total length (TL) (± SE) at time of capture for common carp in Marsh and Pelican lakes, Nebraska in 2006.

RESULTS

A total of 560 common carp was sampled from Marsh Lake and mean CPUE was 2.6 stock-length fish/trap net night. Total length ranged from 87 mm to 709 mm. The size structure was dominated by smaller individuals between 80 mm and 140 mm (Fig. 1). Proportional stock density was 51 (95% CI = ± 20) and RSD-P was 23 (95% CI = ± 16). Marsh Lake demonstrated relatively consistent recruitment through age 7 as no missing year classes were detected (Fig. 2). An abundant 2005 cohort dominated the sample (n=281). Growth of common carp in Marsh Lake was slow (Fig. 3). The von Bertalanffy growth coefficient (*K*) was 0.173 and ultimate length (L_{inf}) was 709 mm.

We observed 100 percent maturity for common carp of both sexes in Marsh Lake by 360 mm. The 50% total length at maturity (both sexes combined) was 312 mm (PROBIT, $\chi^2 = 40.27$, $P < 0.0001$) and the 50% age at maturity was 3.4 years (PROBIT, $\chi^2 = 31.43$, $P < 0.0001$). The smallest mature male was 171 mm while the smallest mature female was 348 mm.

A total of 63 common carp was collected from Pelican Lake and mean CPUE was 12.2 stock-length fish/hour electrofishing. Total length ranged from 90 mm to 865 mm. The size structure of common carp in Pelican Lake was dominated by individuals 600 mm and longer (Fig. 1). Proportional stock density for Pelican Lake was 98 (95% CI = ± 6) and RSD-P was 96 (95% CI = ± 7). The Pelican Lake population exhibited erratic recruitment with several missing year classes not included or not sampled. The population sample was dominated by the age-4 and -5 cohorts (2001 and 2002 year classes), with a maximum observed age of 16 years (Fig. 2). Growth was rapid up to age 4, where they reached asymptotic lengths (Fig. 3). The von Bertalanffy growth coefficient (K) was 0.295 and L_{inf} was 758 mm in Pelican Lake. Common carp exceeded 600 mm by age 4. We were unable to analyze maturity of common carp from Pelican Lake because they were collected after spawning.

DISCUSSION

Common carp population samples from our two study lakes were obtained with different gears and at different times of year, which may preclude direct comparisons between the two samples. However, while we suspect that length-related differences may occur between gears, the use of distinct gears does not explain the difference in recruitment patterns observed in the two lakes. The Pelican Lake population demonstrated erratic recruitment while common carp in Marsh Lake showed consistent recruitment, suggesting that carp recruitment patterns in Nebraska Sandhill lakes may be influenced by factors specific to individual lakes. Phelps (2006) found that common carp recruitment patterns in 18 eastern South Dakota lakes exhibited highly synchronous, erratic recruitment, presumably due to large-scale climatic factors.

We did not determine population abundance for common carp in our two study lakes. However, Pelican Lake likely had only a moderate population abundance based on the mean CPUE of 12.2 stock-

length fish/hour of electrofishing. Paukert and Willis (2000) collected common carp by electrofishing in nine Sandhill lakes, and four had a mean CPUE that exceeded the value for Pelican Lake, maximum CPUE was 77.1 stock-length fish/hr at Home Valley Lake. We had no comparison data for trap-net CPUE, so we cannot assess population abundance of common carp in Marsh Lake based on that index.

Pelican Lake had a 71-cm (28-in) maximum length limit for northern pike in an attempt to increase the abundance of large piscivores and reduce common carp abundance. Sammons et al. (1994) found that northern pike preyed on common carp in midsummer and winter in a South Dakota glacial lake and DeBates (2003) found that pike in Pelican Lake preyed upon age-0 carp in September and October. Furthermore, Pelican Lake has a 38-cm (15-in) minimum length limit for largemouth bass, another piscivore. The common carp population in Pelican Lake was characterized by larger, older, and faster-growing individuals than that of Marsh Lake, which lacked top-level piscivores. A lower overall population abundance in a predator-dominated fish community likely explains the faster growth of common carp in Pelican Lake. In contrast, the common carp in Marsh Lake had no predators; thus, the slower growth rate suggests a population with density-dependent growth.

Population characteristics differed in the two populations examined during this study; therefore, common carp recruitment patterns and factors influencing recruitment patterns in Nebraska Sandhill lakes may need to be assessed on a lake-by-lake basis. Given the substantial influence that this organism can have on entire aquatic ecosystems, we recommend further research to better understand population characteristics of common carp.

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