Journal of Wildlife Diseases, 39(1), 2003, pp. 152–160

SPATIAL AND TEMPORAL CHANGES IN PREVALENCE OF A CLOACAL CESTODE IN WINTERING WATERFOWL ALONG THE GULF COAST OF TEXAS

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ABSTRACT: The cloacal cestode *Cloacotaenia megalops* is one of the most common helminths of waterfowl. We investigated the effect of this parasite on the body condition of wintering waterfowl populations and compared prevalence among age-sex classes, over time and between habitat types on the upper Gulf Coast of Texas (USA) from October 1986–February 2000. Greater than 9,500 birds of 25 waterfowl species were examined for the parasite. There was no statistical difference ($P>0.05$) in body condition between birds with and without the parasite. Average prevalence was lowest for geese ($\bar{x}=3.7\%$) versus 21 to 71% in duck species. Average prevalence was similar ($P=0.81$) between diving ducks ($\bar{x}=46.9\%$) and puddle ducks ($\bar{x}=43.9\%$). Prevalence varied among age-sex classes and was related to sex rather than age. Variation among age-sex classes suggests differences in diet between sexes of duck species on the wintering grounds. There was no evidence for declining prevalence over the wintering period. Prevalence differed ($P<0.05$) between collection sites, and thereby habitat types, for several species. Temporal trends indicate stable prevalence of *C. megalops* for diving ducks and increasing prevalence for puddle ducks. The increasing trend for puddle ducks may indicate declining habitat conditions resulting in increased exposure to the intermediate ostracod host.

Key words: Cestode, *Cloacotaenia megalops, Cypris pubera,* Gulf Coast, waterfowl.

INTRODUCTION

Helminths commonly occur in waterfowl. Under most environmental conditions, the presence of these parasites are thought to have little effect on the survival of their waterfowl hosts (Gower, 1938; McNiel, 1948; Cornwell and Cowan, 1963; Crichton and Wech, 1972; Gray et al., 1989). However, the frequent occurrence of cestodes makes them an important factor in the life histories of waterfowl. Cestodes may cause enteritis, diarrhea, and swelling of the ureters, among other physiological impacts (Wobeser, 1974, 1981). There are also reported instances where helminths may have contributed to the deaths of waterfowl (Hoeve and Scott, 1988). Further, helminth occurrence may have negative nonlethal effects on body condition or reproductive status of waterfowl (Cornwell and Cowan, 1963; Shaw and Kocan, 1980; Gray et al., 1989). Finally, there is concern that diminishing wetland habitat quality and quantity will lead to increased prevalence of parasites, especially helminths, in waterfowl populations as body condition decreases and densities increase (Shaw and Kocan, 1980; Schmid, 1993).

Prevalence of helminths is thought to be greater in hatch-year birds and adult females than adult males because of the greater amount of invertebrates in their diet consumed for rapid growth and recovery from nesting, respectively (Cornwell and Cowan, 1963; Buscher, 1965; Crichton and Wech, 1972; Drobney et al., 1983). Typically, helminths of waterfowl often have an aquatic invertebrate as an intermediate host (Wobeser, 1981). However, by the time wintering grounds are reached, diets of all age-sex classes should be homogeneous so similar prevalence of helminths among ages and sexes within species is expected (Gray et al., 1989). Wobeser (1981) stated that most cestodes have limited host specificity and there is interchange among species, which should

result in similar prevalence values among species for waterfowl groups (i.e., puddle ducks, diving ducks) residing in the same habitat. Further, prevalence of helminths in waterfowl are thought to decline over winter because of the short-lived nature of most helminth infections and decreased availability or inactivity of intermediate hosts (Grower, 1938; Cornwell and Cowan, 1963; Buscher, 1965; Shaw and Kocan, 1980; Wallace and Pence, 1986; Dronen et al., 1994).

Most studies on the prevalence of helminths in waterfowl have occurred on breeding grounds (McDonald, 1969; McLaughlin and Burt, 1979a, b; Shaw and Kocan, 1980). Typically, data collection has been limited to only a small number of birds of a few species for a short period of time. Evaluation of the long-term trends of prevalence of helminths for any population of waterfowl is nonexistent. The previously reported data on the prevalence of parasites in wintering waterfowl are similarly limited (Schmid, 1993; Dronen et al., 1994). Examination of relationships among parasite occurrence and waterfowl body condition, habitat types, and temporal trends may give insight into survival, habitat conditions, management, and species-specific predisposition for infection (Buscher, 1965; Drobney et al., 1983). The upper Gulf Coast of Texas (USA) is the most used wintering area for waterfowl of the Central Flyway (Haukos, 2001). Therefore, any factors affecting habitat use, survival, and condition of wintering waterfowl on the upper Gulf Coast could have meaningful impacts on the flyway population.

The cestode *Cloacotaenia megalops* (Nitzsch, 1829) (Wolffhugel, 1938; syn. *Hymenolepis megalops*) is one of the most common helminths in waterfowl (Gower, 1938; McDonald, 1969; McLaughlin and Burt, 1979a; Schmid, 1993). Yet, little is known of the prevalence and potential effects of this parasite in wintering populations of waterfowl. The objectives of our study were to investigate the influence of *C. megalops* on body condition of waterfowl populations wintering on the upper Gulf Coast of Texas and compare the prevalence of *C. megalops* in wintering waterfowl populations among age-sex classes, between habitat types, and across seasons on the upper Gulf Coast of Texas.

MATERIALS AND METHODS

Bird collection and measurements

From October 1986 to February 2000, hunter-check stations were manned on public hunt units of Anahuac (Chambers County), McFaddin (Jefferson County), and San Bernard (Brazoria County) National Wildlife Refuges (NWRs) on the upper Gulf Coast of Texas. Over 95% of measured ducks were harvested on Anahuac and McFaddin NWRs. The East Hunt Unit of Anahuac NWR is 4,148 ha in size (29°59′N, 94°27′W) and characterized by 1,936 ha (46.7%) of open land habitats, of which rice rotation is a major component (1986 1,336 ha, 2000 728 ha), 700 ha (11.7%) of brackish marsh, 1,066 ha (25.7%) of intermediate marsh, and 230 ha (5.2%) of fresh marsh. The Public Hunt Unit of McFaddin NWR represented by the check station data is 4,538 ha in size (29°42′N, 94°7′W) and comprised of 4,121 ha (90.8%) of intermediate marsh and 417 ha (9.2%) of brackish marsh. Additional goose data were collected in conjunction with hunting guides operating in areas surrounding the cities of Katy (29°59′N, 95°46′W) and Eagle Lake, Texas. Geese were principally harvested over rice and other crop fields in this area.

The range of marsh types found on the NWRs is represented by water salinity ranges (parts per thousand, ppt) and determine habitat type and quality. The greater the diversity in low and mid-levels of plant succession, the greater amount of waterfowl use of manipulated habitat when adequate water levels are present (Stutzenbaker and Weller, 1989). The brackish marsh has the highest salinity (3.5–10 ppt, average 8 ppt) of these marsh assemblages, resulting in lower plant diversity. As salinity decreases, plant diversity increases (Stutzenbaker and Weller, 1989; Stutzenbaker 1999). Brackish marshes are transitional marshes occurring between the saline (nearest to Gulf water exposure) marsh and the more inland intermediate marsh type. Dominant plant species include marshhay cordgrass (*Spartina patens*), seashore saltgrass (*Distichlis spicata*), saltmarsh bulrush (*Scirpus robustus*), dwarf spikerush (*Eleocharis parvula*), and widgeongrass (*Ruppia maritima*).

The intermediate marsh type (0.5–3.5 ppt) occurs between brackish and fresh marsh or

may occur as inclusions in the brackish marshes. The dominant plants are marshhay cordgrass, seashore paspalum (*Paspalum vaginatum*), common reed (*Phragmites australis*) Olney bulrush (*Scirpus americanus*), sand spikerush (*Eleocharis montevidensis*), cattail (*Typha* spp.), and sago pondweed (*Potamogeton pectinatus*).

The inland open fresh marshes (<0.5 ppt) are dominated by a wide variety of plants. Major dominant emergent plants include marshhay cordgrass, giant cutgrass (*Zizaniopsis miliacea*), barnyard grass (*Echinochloa crusgalli*), smartweeds (*Polygonum* spp.), delta duck potato (*Sagittaria platyphylla*), beggar's tick (*Bidens laevis*), and burhead (*Echinodorus rostratus*). The long list of floating and submerged aquatics include white water lily (*Nymphaea odorata*), water hyacinth (*Eichhornia crassipes*), common bladderwort (*Utricularia vulgaris*), and longleaf pondweed (*Potamogeton nodosus*).

Despite Anahuac and McFaddin NWRs being essentially adjacent and similar in size, habitat conditions for wintering waterfowl are quite different. McFaddin contains 90% intermediate marsh compared to the 25% at Anahuac. Furthermore, much of McFaddin NWR is nearly inaccessible by hunters compared to the nearly total access that occurs at Anahuac NWR because of the extensive fragmentation of the hunt area via levees, canals, drainage ditches, reservoirs, cattle walkways, bayous, oil and gas exploration and drilling, and rice-field construction. Therefore, birds at Anahuac experience more human disturbance and potentially higher stress than those at McFaddin. Habitat quantity and quality for wintering waterfowl (ducks and geese) also differs between the two refuges with Anahuac marshes at a lower elevation resulting in more frequent salt water influence, which contributes to increased nutrient cycling and plant communities in a lower successional level because of the greater intensity of ecologic disturbance.

Dates of refuge hunter-check stations establishment were based on annual hunting regulations (i.e., season opening and closing dates), with the intent of similar sampling effort of harvested birds among years. Check stations were manned each month of the hunting season, with three periods targeted: season opening weekend, any split-season opener, and the end of the hunting season. Each harvested bird was identified to species, sexed, and aged. Ducks were aged and sexed via tail- and wing-feather characteristics (Carney, 1992). Geese were aged based on tail-feather characteristics and sexed using cloacal examination. All birds were measured and examined by one person (J.N.). Excess moisture was wiped from the birds prior to body measurements. Disfigured birds were excluded from the data set. Wing chord was measured in cm from the anterior edge of the carpometacarpus to the tip of longest primary. Body mass was measured with an electronic scale to the nearest gram. A condition index was calculated for each bird as body mass (g) divided by wing chord (cm). This index was used because 1) models to estimate fat of waterfowl wintering (sensu Ringleman and Szymczak, 1985) on the Gulf Coast have not been established and 2) this ratio is the most common condition index reported for waterfowl (Haukos et al., 2001). Presence of the large *C. megalops* is easily determined through visual examination of the cloaca (Doster and Goater, 1997). Species identification was conducted as described in Schmid (1993).

Data analyses

Greater than 90% of examined birds in which *C. megalops* was found only contained one individual of the parasite; rarely were greater than two individual parasites found in a bird. Therefore, data were primarily analyzed based on presence or absence of the parasite. The effect of the presence of *C. megalops* on body condition was determined with a two-way analysis of variance comparing dependent variables (i.e., wing chord, body mass, and condition index) among sex-age classes and presence/absence of cloacal parasites (Sokal and Rohlf, 1981; SAS Institute, 1985). A *t*-test was used to compare average prevalence of a cloacal parasite between diving and dabbling ducks (Sokal and Rohlf, 1981; SAS Institute, 1985). To assess long-term temporal trends in the prevalence of a cloacal parasite, regression analyses of running three-season average percentages of prevalence were conducted for each species and species groups (i.e., dabbling and diving ducks). Loglinear models (i.e., *G*-tests) were used to compare prevalence across sex-age classes, months, and between areas within each species (Sokal and Rohlf, 1981; SAS Institute, 1985).

RESULTS

During 14 yr of study, 9,521 birds of 25 species of waterfowl were examined for *C. megalops.* Average prevalence was lowest for geese ($\bar{x}$=3.7%, range 2.8–4.7%). Despite variation among species, average prevalence was similar (t=0.25, 10 df, P=0.81) between diving ducks ($\bar{x}$=6.9%, range 27.7–61.5%) and puddle ducks

TABLE 1. Prevalence (%) of *Cloacotaenia megalops* in hunter-killed birds across age-sex classes for waterfowl wintering on the upper Gulf Coast of Texas, 1986–2000.

Species	Adult		Juvenile		*G*	*P*
	Female	Male	Female	Male		
Blue-winged teal (*Anas discors*)	59.6	59.3	60.7	68.6	3.7	0.29
Green-winged teal (*A. crecca*)	32.9 AB[a]	18.3 C	39.5 A	30.3 B	63.7	<0.001
Gadwall (*A. strepera*)	71.1	70.4	71.3	70.4	0.1	0.99
Mallard (*A. platyrhynchos*)	68.8 A	33.1 B	64.4 A	42.4 B	31.8	<0.001
Mottled duck (*A. fulvigula*)	46.2 A	28.1 B	47.5 A	27.6 B	24.2	<0.001
Northern pintail (*A. acuta*)	31.9 AB	11.7 C	44.7 A	25.6 B	29.3	<0.001
Northern shoveler (*A. clypeata*)	58.2 AB	56.9 A	67.8 B	68.9 B	7.9	0.05
American wigeon (*A. americana*)	35.0 A	16.8 B	25.6 A	15.2 B	14.2	0.003
Lesser scaup (*Aythya collaris*)	32.6	23.6	29.4	27.5	3.9	0.27
Ring-necked duck (*Aytha affinis*)	58.7	50.6	66.7	56.0	4.2	0.24

[a] Age-sex classes followed by the same uppercase letter do not differ within species.

($\bar{x}$=3.9%, range 20.7–71.1%). Greater white-fronted (*Anser albifrons*) and snow geese (*Chen caerulescens*) were excluded from further statistical analyses because of low prevalence of *C. megalops.*

Analyses of body measurements, condition, and prevalence were limited to those species where greater than 300 birds were examined (Table 1). There were no differences in wing chord, body mass, and condition index between birds with and without *C. megalops* for any species (P>0.05, Table 1).

Long-term trends of cloacal parasite occurrence, based on running three-season calculations, showed considerable annual fluctuations in the prevalence of *C. megalops* with slightly increasing trends for dabbling ducks and stable for diving ducks (Fig. 1). Comparing dabblers and divers indicates contrasting temporal trends of *C. megalops* prevalence since the early 1990s (Fig. 2), with dabblers increasing (r=0.68,

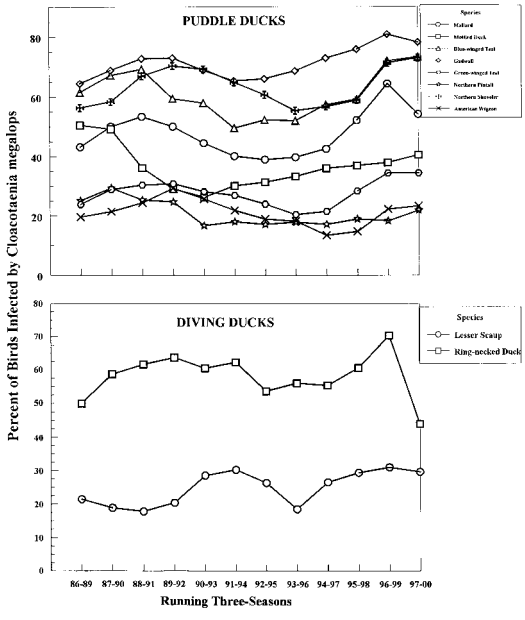

FIGURE 1. Percent occurrence of *Cloacataenia megalops* calculated over running three-season (November–January) periods for eight species of puddle ducks and two species of diving ducks harvested from 1986–2000 on the upper Gulf Coast of Texas.

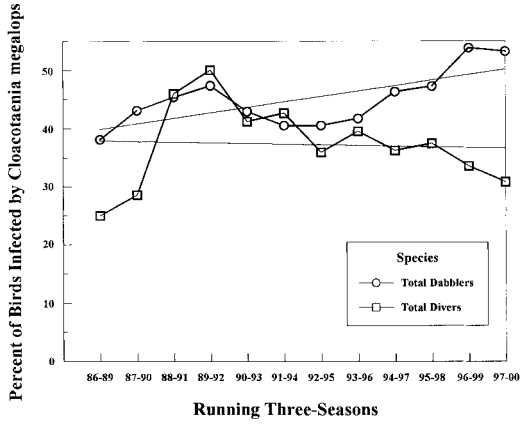

FIGURE 2. Combined percent occurrence of *Cloacataenia megalops* calculated over running three-season (November–January) periods for eight species of puddle ducks and two species of diving ducks harvested from 1986–2000 on the upper Gulf Coast of Texas.

TABLE 2. Prevalence (%) of *Cloacotaenia megalops* in hunter-killed birds across months for waterfowl wintering on the upper Gulf Coast of Texas, 1986–2000.

Species	Month					*G*	*P*
	Sept.	Oct.	No.v	Dec.	Jan.		
Blue-winged teal	68.4 A[a]	76.9 A	55.6 C	66.7 AB	62.1 BC	10.2	0.04
Green-winged teal		33.3	30.6	27.1	25.2	1.3	0.08
Gadwall			71.0	72.3	69.0	1.3	0.52
Mallard			49.5	46.2	51.2	0.6	0.73
Mottled duck			38.9	31.8	30.4	4.5	0.10
Northern pintail		15.4	28.0	21.4	17.1	4.8	0.19
Northern shoveler			66.3	65.0	58.5	3.3	0.20
American wigeon			25.1	20.7	16.5	4.3	0.12
Lesser scaup			24.8	29.8	27.5	1.1	0.57
Ring-necked duck			52.2	54.8	64.6	4.2	0.12

[a] Monthly values followed by the same uppercase letter do not differ within species.

slope=0.93) in parasite occurrence and divers experiencing stable conditions ($r=-0.06$, slope=−0.11).

Prevalence of *C. megalops* among age-sex classes contrasted across species (Table 1). Deviations in prevalence within species appear to be related more to sex than age. There were no differences in prevalence among age-sex classes for blue-winged teal, gadwall, ring-necked duck, and lesser scaup. Prevalence was greater in females than males for mallard, mottled duck, northern pintail, and American wigeon. Juveniles exhibited a greater prevalence than adults for northern shovelers. Finally, in green-winged teal, adult males had lower prevalence than other age-sex classes.

A statistical difference in prevalence of *C. megalops* across months was found only in blue-winged teal (Table 2). Decreasing trends in prevalence were found in green-winged teal, mottled duck, northern pintail, northern shoveler, and American wigeon. Ring-necked duck showed an increasing trend in prevalence over winter.

Differing patterns among species were also present when prevalence of *C. megalops* was examined between collection sites (Table 3). Blue-winged teal exhibited greater prevalence when collected at Anahuac NWR. Greater prevalence in birds collected at McFaddin NWR was found for gadwall, green-winged teal, ring-necked duck, and northern shoveler. Mallard, mottled duck, northern pintail, American wigeon, and lesser scaup had

TABLE 3. Prevalence of *Cloacotaenia megalops* in hunter-killed birds between collection sites for waterfowl wintering on the upper Gulf Coast of Texas, 1986–2000.

Species	Collection site		*G*	*P*
	Anahuac NWR	McFaddin NWR		
Blue-winged teal	51.6	31.4	20.6	<0.001
Green-winged teal	24.0	30.6	10.3	<0.001
Gadwall	67.6	72.8	4.6	0.03
Mallard	48.7	55.1	1.2	0.28
Mottled duck	33.3	36.4	0.6	0.42
Northern pintail	19.2	21.0	0.2	0.69
Northern shoveler	58.2	67.8	6.1	0.01
American wigeon	20.9	20.8	0.001	0.98
Lesser scaup	28.6	27.5	0.1	0.75
Ring-necked duck	48.0	60.0	5.0	0.03

similar prevalence levels between the two refuges.

DISCUSSION

The only known intermediate host of *C. megalops* is the ostracod *Cypris pubera,* which is thought to be active only during spring and early summer in the benthos of wetlands (McDonald, 1969; Delorme, 1991). By foraging in uplands, geese are infrequently exposed to the intermediate host of *C. megalops* resulting in the low prevalence of the parasite. Dabbling ducks with their generalist diet were expected to have higher prevalence of *C. megalops* compared to diving ducks. The similar prevalence between dabbling and diving ducks was likely a result of the variation in prevalence among species within both groups.

The *C. megalops* infection rates of 73% for gadwalls, 62% for ring-necked ducks, and 38% for mottled ducks reported by Schmid (1993) were similar to those found in our study (71.1% gadwalls, 57.8% ring-necked ducks, 35.2% mottled ducks). In Oklahoma, Shaw and Kocan (1980) trapped birds between March 1976 and April 1977 and reported prevalence of mallard 73.9%, wigeon 36.3%, blue-winged teal 72.2%, and green-winged teal 57.9%, all of which are greater than found in our study. Interestingly, Dronen et al. (1994) did not find *C. megalops* in mallards wintering in post-oak savannah of Texas. In playa wetlands of northwest Texas, Fedynich (1993) reported prevalence of 59% for mallards, which was greater than for mallards on the upper Texas Gulf Coast.

There were no statistical differences in body mass, wing chord, or body condition index between birds with and without *C. megalops.* Schmid (1993), working in the same area, did not find a correlation between body mass and parasite load in gadwalls. Other studies have also failed to find a correlation between body mass or body condition and parasite burdens (Gower, 1938; McNiel, 1948; Crichton and Welsh, 1972; Gray et al., 1989).

The increased prevalence on McFaddin NWR for four species was unexpected. Drobney et al. (1983) declared that cestode fauna was directly related to the type of food ingested. In a previous study, Haukos et al. (2001) reported that most waterfowl species had higher body condition values on McFaddin NWR compared to Anahuac NWR. They attributed this to decreased disturbance and ability to feed undisturbed in the marsh. Perhaps undisturbed feeding in the coastal marsh leads to increased contact with the intermediate host *C. pubera* leading to the increased prevalence of *C. megalops.* Moreover, vegetation associations of *C. pubera* are unknown, but differences in prevalence between the refuges may be due to differing plant communities with those at McFaddin favoring *C. pubera.*

The variation in prevalence of *C. megalops* among age-sex classes throughout winter for some species somewhat contradicts previous thought of similar prevalence of helminths among age-sex classes during winter. Reasons for these differences are not clear, but are likely related to differences in feeding habits and forage selection between sexes, given the mixed assemblages of age-sex classes on the wintering grounds. Schmid (1993) working in the same area, found no differences in total internal parasite load among age and sex classes of gadwalls, mottled ducks, and ring-necked ducks. Fedynich (1993) indicated that sex was not an important factor for mallards in playas wetlands, but a difference in prevalence existed between sexes for mallards in this study. However, *C. megalops* has a different life cycle compared to most cestodes in that it appears to remain with the definitive host for prolonged periods (Buscher, 1965); therefore it is difficult to isolate infection, which may be occurring in areas other than the wintering grounds. This alone could explain age-sex class differences except for the evidence of apparent infection on the win-

tering grounds and the finding of differing prevalence between collection sites.

Similarity of helminth prevalence among age-sex classes indicates foraging on the same intermediate hosts (Buscher, 1965). Unfortunately, ecology of the intermediate ostracod host *C. pubera* in Gulf coastal marshes is unknown. Furthermore, it is unknown if *C. pubera* is the only intermediate host of *C. megalops.* Shaw and Kocan (1980) believed that other intermediate hosts were present but have yet to be identified. Given the greater than 400 species of ostracods in North America (Delorme 1991), it is likely that another intermediate host of *C. megalops* exists. Vogtsberger (1999) reported the presence of *Ostracoda* species during each month in the coastal marsh of Anahuac NWR but did not report monthly occurrence of species such as *C. pubera.* The differences in prevalence in this study likely indicates some difference in diet among age-sex classes even during the wintering period. Therefore, combining sex and age classes for parasite work and subsequently food selection on the wintering grounds may mask apparent differences within species.

It is apparent that infection of *C. megalops* can occur on the wintering grounds as proposed by Shaw and Kocan (1980) and Dronen et al. (1994), especially in habitats such as coastal marshes where freezing conditions are rare. This is supported by most species exhibiting steady or increasing prevalence over wintering and differences in prevalence between collection areas during our study. Shaw and Kocan (1980) indicated that helminth diversity peaked in August and was lowest in late winter and early spring. Buscher (1965) reported that cestodes reached infection peaks in August (*C. megalops,* 91% in August and 50% in winter). However, this trend was not evident in several species during this study, with prevalence remaining relatively constant over the wintering period for most species and even an increasing trend for ring-necked ducks. Patterns reported by Schmid (1993) for gadwall (76% early winter and 68% late winter) and ring-necked duck (50% early and 80% late) are similar to those in our study. However, her findings for mottled duck (33% early and 43% late) showed an increasing trend that differed from our findings of a decreasing trend. Wallace and Pence (1986) reported a nearly 50% decline in prevalence in *C. megalops* in waterfowl from fall (76%) and spring (37%). Fedynich (1993) indicated that acquisition of helminths occurred primarily during summer, but *C. megalops* exhibited temporal persistence for adults and juveniles throughout the four seasons for birds using playa wetlands, another critical wintering area for waterfowl of the Central Flyway.

There may be cause for some concern with evidence of increasing prevalence of the cloacal parasite over time for dabbling ducks. This trend may be indicative of declining habitat quality and/or quantity for dabbling ducks resulting in increased incidence of parasite infection. The decline in habitat for dabbling ducks may be due to increased human and ecological disturbance, intrusion by increasing numbers of geese, or improper cattle management, among other reasons. Pennak (1989) and Delorme (1991) indicate that unlike many species of ostracodes, *C. pubera* is relatively large and can survive in a wide range of environmental conditions including long periods of stagnation and oxygen exhaustion on lake bottoms (DO 0–20 mg/l, bottom temp 5–30 C, with a mean annual range of temp of −1–5 C), thus increasing the relative abundance of this species as habitat conditions decline and other ostracod species are lost. Further, it is likely that this species survives the increasing amount of salt water, the intrusion of which steadily increased in frequency over the course of the study. However, the increase in prevalence also corresponds with increasing continental populations of waterfowl, increasing the density of birds on their habitats, which may make individuals more susceptible to parasite infection.

ACKNOWLEDGMENTS

Previous drafts of the manuscript were reviewed by G. Esslinger, J. Haskins, B. Johnson, D. Pence, L. Smith, and B. Wilson. Support for the study was provided by Texas Chenier Plain National Wildlife Refuge Complex and US Fish and Wildlife Service, Region 2, Migratory Bird Office.

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Received for publication 4 January 2002.