Highly nutritious marsh vegetation as a magnet for swans

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Summary

This study revealed an unusual movement of Mute and Trumpeter swans to Cranberry Marsh in 2017 following a severe drought and drawdown. The swans were non-breeding birds of various ages that typically do not move much in the May-June period as they prepare for wing moult. They were apparently attracted by an abundance of highly nutritious food, especially high protein sago pondweed. This concentration of swans lasted only as long as the nutritious food lasted and swans left as soon as the supply of this desirable food was exhausted. In addition to high protein content, sago pondweed phosphorus levels in Cranberry Marsh were considerably higher than adjacent marshes. This is attributed to differences in watershed characteristics and phosphorus sources.

Introduction

Cranberry Marsh in Whitby, Ontario (43° 50.5' N, 78° 57.5'W), is an ancient bay of Lake Ontario (Figure 1). It is unusual in that it is separated from Lake Ontario only by a barrier beach which is not particularly stable and through which seepage occurs which lowers water levels over the summer (Lumsden 2018). The bottom of the marsh is lined with blue clay through which there can be little or no seepage into the subsoil. At intervals, the marsh has dried out, usually because the beach washed out when high water topped it at breakup time or once after a thunderstorm in June (Lumsden, pers. obs.).

When water levels are stable in a marsh, bacteria sequester nutrients into the substrate where they accumulate. The water column gradually loses fertility. When water is withdrawn and the marsh dries out, oxygen then reaches the mud. With the return of water, stored nutrients are oxidized and return to solution. They create fertile, productive marsh conditions to which vegetation and marsh birds respond (Kadlec 1962, Neckles *et al.* 1990, Lumsden *et al.* 2015).

Mute Swans (*Cygnus olor*) (hereinafter Mutes) have responded over the years to the alternating sequestration and release of nutrients in Cranberry Marsh

Figure 1. Cranberry Marsh, near Whitby, Ontario, where an unusual concentration of swans occurred in spring-early summer 2017. Observation locations for swan counts (see text) are indicated by symbols.(✦)

(Lumsden 2018). Following repair of a breach in 1983, eight pairs nested and in 1984, seven pairs nested in the marsh. The Central Lake Ontario Conservation Authority, with assistance from Ducks Unlimited Canada, conducted a complete drawdown and constructed an overflow spillway on the barrier beach in 2001. When this was completed, water level was returned to normal. On 11 May 2004, an aerial survey found six Mute nests and 15 Mutes in the marsh. In 2011, after seven years of stable water levels, a search of the marsh by canoe in May found only one Mute nest. In 2012, only one Mute brood, six Mutes and six Trumpeter Swans (*C. buccinator*) were present.

Water levels remained stable until 2016 when an unusually severe drought due to low winter and spring precipitation dried the marsh. It started to fill with the fall and winter rains. Runoff in the spring of 2017 filled the marsh completely and we assume there was the usual strong flush of nutrients from the substrate that usually follows such events. Starting in February 2017, unusually large numbers of swans, mostly Mutes but some Trumpeter Swans,

Figure 2. Locations of Cranberry Marsh and neighbouring marshes from which sago pondweed samples were collected for nutrient analysis comparison. (●)

visited the marsh (Lumsden *et al.*, pers. obs.). This study reports on swan numbers, aquatic vegetation nutrient content and the factors that influenced swan movements in 2017.

Methods

Between 10 April and 8 June 2017, we counted swans eight times, starting in the morning between 10:54 hr and 11:02 hr each day. Counts were the first thing done upon our arrival and were completed in just over one hour. They were made from three observation platforms, one on the east side of the marsh and two on the west (Figure 1).

Samples of sago pondweed (*Stuckenia pectinata,* formerly *Potamogeton pectinatus*) were collected for nutrient analysis on 5 June from five sites about 50 m apart across the middle of Cranberry Marsh. Water depth at these sites on 5 June was 122.20 cm ± 44.38 cm (range 80-160 cm, N = 5). The upper parts of the sago pondweed plants had been grazed by the swans so that only the root portion was left (length = 21.66 cm ± 6.62 cm, range 12.7-33.0 cm, N = 5). These portions were scraped from the substrate with a leaf rake. They were washed and dried for one hour and frozen. Nutrient analysis on all samples was performed by Laboratory Services (Agriculture and Food Laboratory), University of Guelph. Percentage of protein (protein= nitrogen x 6.25) (Leeson and Summers 1997), calcium, phosphorus and magnesium were measured on freeze-dried material.

Adjacent to Cranberry Marsh, three marshes with Mute territories were chosen for comparison: Duffins Creek (43°49' N, 079° 02' W), 6.5 km west of Cranberry containing two territories, St. Mary's on the West Side Creek (43°53' N, 078°41' W), 24 km east of Cranberry, containing one territory and Bowmanville Creek (43°53' N, 078° 40' W), also 24 km east of Cranberry, containing two territories (Figure 2). Samples of sago pondweed were collected on 30 July (N= 5) and 3 September (N= 4) from each Mute territory in these marshes. The percentage values and standard deviations of protein, calcium, phosphorous and magnesium in these marshes are given in Table 2. T-tests were used to determine if differences were significant at the $P < 0.05$ level.

Results

Our eight counts between 10 April and 8 June 2017 recorded varying numbers of swan visitors (Table 1, Figure 3). Three groups of swans (2, 2 and 10) were seen arriving but none were seen leaving during our one-hour counts. Origins of the birds are unknown as were their daily movements. After 16 May, there was a steady rise to a peak on 27 May (107 swans) and then a rapid decline in numbers (Figure 3). Swans probably left because of depletion of food (see below).

In adjacent marshes (Duffins Creek East and West, St. Mary's Marsh and Bowmanville North and South), the collection from 30 July had an overall mean protein content of 10.85 ± 3.36% compared with a 3 September overall mean of 9.45 ± 2.00%. The difference was not significant ($t = 0.5943$, DF 9, $P > 0.05$). These samples were therefore combined (10.15%) for comparison with the Cranberry Marsh collection of 5 June (23.31%). The difference between Cranberry Marsh and these marshes in pondweed protein content was highly significant ($t = 14.8616$, DF 14, $P < 0.001$) (Table 2).

Phosphorus content in pondweed from Cranberry Marsh on 5 June was relatively high (0.81%) compared to the collections from the five neighbouring marshes made on 30 July (0.21%) and on 3 September (0.15%). The difference was highly significant ($t = 5.0166$, DF 15, $P < 0.001$).

Table 1. The number of Mute territory holders and visiting Mute and Trumpeter Swans on eight counts in early spring and summer in Cranberry Marsh in 2017.

Date	Territory Holders ♂ and ♀	Visitors Mutes	Visitors Trumpeters	Total Visitors	Total Swans
10 April	11	29	6	35	46
18 April	9	27	4	31	40
16 May	10	63	0	63	73
22 May	12	80	2	82	94
27 May	13	80	14	94	107
30 May	13	61	0	61	74
1 June	12	46	6	52	64
8 June	10+	18	5	23	33

Table 2. Mean (± Standard Deviation) percentage nutrient content on a dry weight basis of sago pondweed in Cranberry Marsh on 5 June and in five neighbouring marshes along Lake Ontario on 30 July and 3 September 2017.

	Protein	Calcium	Phosphorus
Cranberry Marsh			
5 June (N=5) lower 21.66 cm	23.3 ± 1.4	3.9 ± 1.2	0.8 ± 0.1
Neighbouring marshes			
30 July N=5/marsh			
Duffins Creek East	7.8 ± 2.2	18.4 ± 4.9	0.1 ± 0.0
Duffins Creek West	6.9 ± 1.1	17.7 ± 1.9	0.2 ± 0.0
St. Mary's Marsh	14.1 ± 4.8	11.1 ± 6.1	0.3 ± 0.2
Bowmanville North	11.8 ± 5.4	13.1 ± 4.1	0.2 ± 0.2
Bowmanville South	13.8 ± 5.7	14.3 ±2.5	0.3 ± 0.4
Neighbouring marshes combined			
30 July N=25	10.9 ± 3.4	14.9 ± 3.7	0.2 ± 0.2
Neighbouring marshes			
3 September N=4/marsh			
Duffins Creek East	8.6 ± 1.5	14.7 ± 3.5	0.1 ± 0.0
Duffins Creek West	9.6 ± 1.9	11.2 ± 3.1	0.1 ± 0.0
St. Mary's Marsh	9.8 ± 0.8	8.4 ± 3.1	0.1 ± 0.0
Bowmanville North	9.5 ± 1.8	13.3 ± 4.1	0.2 ± 0.1
Bowmanville South	1.0 ± 0.7	14.3 ± 2.5	0.2 ± 0.0
Five neighbouring marshes combined			
3 September N=20	10.2 ± 1.3	12.4 ± 4.7	0.2 ± 0.2

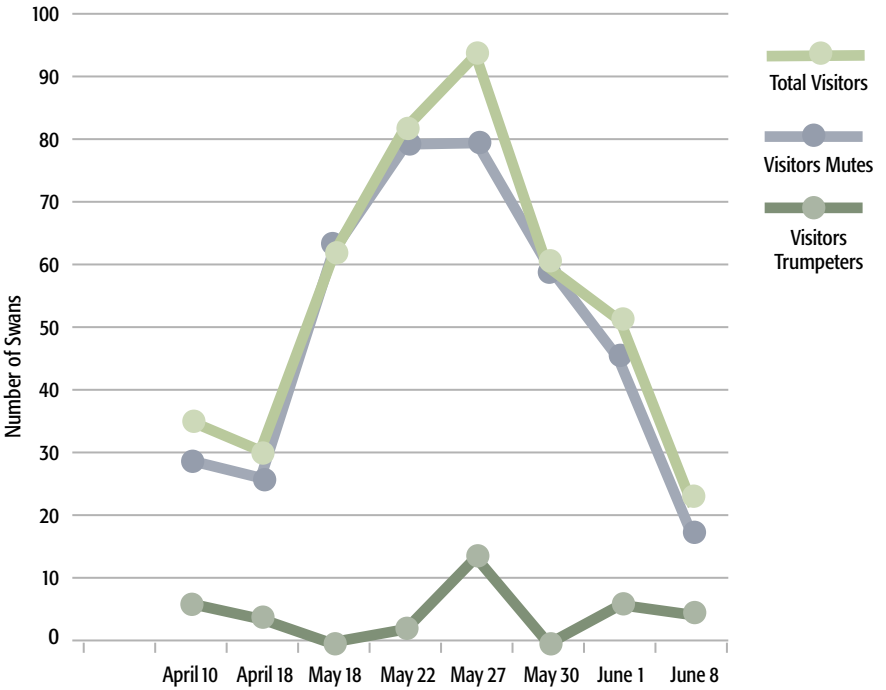

Figure 3. The number of swans visiting Cranberry Marsh by date in the spring of 2017. Note the decline in number approaching 5 June, the date on which sampling of sago pondweed showed that stems of sago pondweed had been grazed down to a length of only 21.66 cm.

Discussion

Like most neighbouring marshes, Cranberry Marsh freezes every winter and local swans must move to winter in areas of open water. It is likely that because of their travels in fall and spring, many Mutes of the region have moved regularly through Cranberry Marsh and have become familiar with the area over the years. The many visitors that came in the spring of 2017 (Figure 4) were mostly unemployed, non-territorial adults, subadults and yearling offspring ousted from their natal areas. Breeding pairs would have been anchored locally in their home marshes by their territorial duties.

The visitors did not spread evenly over the marsh; they occupied the open marsh beyond the fringe of cattail (*Typha spp.*) which framed its border. They did not enter the alder dominated south-central part of the marsh. They concentrated in the open part of Mute territories which contained rich beds of sago pondweed and covered an estimate of 14.7 ha of the 21.9 ha marsh (Lumsden 2018). The visitors were most interested in feeding and gave way on the approach of a territory holding resident. The latter were unusually tolerant of these intruders. While sometimes maintaining the threat posture, they tipped, up-ended

Figure 4. Mute Swan visitor landing in Cranberry Marsh on 31 May 2019. *Photo: Gerry Markhoff*

Figure 5. Social groups of 10-20 swans periodically occupied part of the open marsh.
Photo: Gerry Markhoff.

and fed almost continuously and seldom stopped to chase a visitor.

Visiting swans were found in a number of social groups which could be distinguished by their flock cohesion or often as yearling broods. Observations showed that within a concentration, individuals spaced themselves approximately 2-5 m apart (Figure 5). Social groups of 10-20 swans might be separated from other groups by about 100 m or more. At any one time, the entire flock of visitors occupied only part of the marsh. At each daily check, we found that they occupied a different sector. At the peak of numbers on 27 May 2017, 80 non-territorial Mutes and 14 Trumpeters visited Cranberry Marsh. Badzinski (2017) estimated that in mid-August, there were 241 Mutes on the shore of Lake Ontario between McLaughlin Bay (43°42'N, 78° 49'W) and Toronto Harbour in 2017, a distance of about 55 km. The majority (229) were adults and most were unemployed as only seven broods and 12 cygnets were counted. Most adults (162) were in the Whitby Harbour/Lynde Creek area between Port Whitby and Pickering Beach with another 51 adults in Toronto Harbour and islands. The 80 Mute visitors to Cranberry Marsh constituted one-third of the Badzinski (2017) total and some of the visitors may have come from a considerable distance as our records show relatively small numbers in the immediate vicinity of Cranberry Marsh (Lumsden, unpublished data).

The swans imposed substantial grazing pressure on the marsh. From 10 April to 8 June (59 days) there were 13 territory holders (six pairs and one male) that exerted 767 swan-days of grazing pressure on 14.7 ha of marsh or just over 52 swan-days/ha. This was similar to that of earlier years (Lumsden, unpublished data) and we have no evidence that this level of grazing pressure was excessive. At the same time, there were 23-94 (average 55) visiting swans per day. Thus over 59 days, the visitors imposed 3245 swan-days (Table 1) of additional grazing pressure, or 221 swan-days of grazing pressure/ha; this is over four times that imposed by the residents. It is not surprising that such pressure had a similar effect on the vegetation at Cranberry Marsh as that described in Rhode Island and Chesapeake Bay. In Rhode Island, Allin and Husband (2003) found that flocks of moulting Mutes, in shallow sandy areas, reduced the biomass of submerged aquatic vegetation (SAV) by 95% causing extensive damage. Tatu *et al.* (2007) found that the social status of the Mutes present in Chesapeake Bay had an important effect on grazing pressure. Pairs reduced SAV cover by 32-75% while the impact of non-territorial flocks was 75-100%. O'Hare *et al.* (2007) documented similar grazing impact of Mutes in southern England.

The very high nutrient content of the pondweed (23.3% protein) and presumably other submerged aquatic vegetation at Cranberry Marsh in 2017, once it had been detected by the swans, apparently acted as a cue that decoyed others from a substantial area. The protein-rich food was so desirable that they grazed sago pondweed down to an average length of only 21.66 cm (above the root) by 5 June. Since water depth was 122 cm, it is

probable that they ate all that they could reach, exhausting the supply and thereafter leaving the marsh by 11 June. The residents, because they were well into their nesting cycle, had no choice but to stay. Included in their territories were channels and openings in the cattail fringe surrounding the marsh, which were ignored by the visitors. There was an abundance of sago pondweed and other species, notably duckweed (*Lemna*) there. *Lemna* is an excellent nutritious swan food (Men *et al.* 2001, Lumsden *et al.* 2017). With other SAV, it provided ample rations for the local nesters.

The availability of dietary calcium has a substantial influence on well-being and the breeding distribution of many bird species including swans and geese (Lumsden 1984, Graveland and Van Gÿzen 1994, Mänd *et al.* 2000, Bureš and Weidinger 2001, Reynolds and Perrins 2010). For wild swans, any calcium level above 0.8-0.85% (that which is provided in domestic rations) can be considered to be adequate. In Cranberry Marsh in the 5 June collection, the calcium level was 3.9%, much lower than that in the adjacent marshes but more than adequate (Table 2). Cranberry is not fed by a creek; its water comes from precipitation and runoff from its small watershed. The soil type in its watershed is Smithfield Clay Loam, which is slightly above neutral with a pH of 7.2. The calcium content of the sago pondweed samples collected on 30 July and 3 September in four neighbouring marshes ranged from 11.2-18.4%. These creeks have their headwaters rising in the calcium rich Oak Ridge's Moraine. The West Side Creek, which is only about 3 km long, feeds the fifth, St. Mary's Marsh, which had 8.4% calcium (Table 2).

There is a relatively low absorption rate of calcium by birds from the daily intake of food, no matter how abundant it may be. All of these marshes (including Cranberry) provided adequate calcium for their daily needs but swans face extra demands for shell formation at the time of laying. Trumpeters (Lumsden, unpublished), and probably Mutes, solve this problem by storing medullary bone in the femur, tibiotarsus and tarsus prior to the egg-laying period (Reynolds and Perrins 2010, Lumsden 1984) and accessing these stores at the time of egg shell formation.

An important change took place within the growing season in Cranberry Marsh in 2017. On 22 July, when we checked sago pondweed in the centre of the marsh, we found that much of the surface was covered with dense floating patches of decomposing *Spirogyra* algae (blanket weed or water silk). It has been known for a long time that phosphate from detergents in sewage treatment plant effluent and runoff of phosphate rich agricultural fertilizers produces massive algal blooms (Maidstone and Parr 2002, Fried *et al.* 2003). There are no sewage outfalls in Cranberry Marsh; a large part of its very small, non-intensively farmed watershed is composed of woodland. The origin of its phosphate is unlikely to have had been external. It must have originated internally, probably from the release of the sequestered nutrients in its substrate following the drought. We have no direct measurement of phosphorus in its water column. Indirect evidence of high phosphorus

levels is provided by the phosphorus content (0.81%) in the pondweed samples collected on 5 June. This must have been originally derived from years of accumulation in the substrate. For comparison, we have the phosphorus content in the five Ontario marshes which are fed by creeks draining extensive agricultural land and ultimately sewage plants. The collections from these marshes made on 30 July contained 0.21% phosphorus and on 3 September contained 0.15% phosphorus. The levels in Cranberry Marsh are three to eight times higher than those of the neighbouring marshes. It seems likely that the *Spirogyra* bloom was activated in Cranberry Marsh by the presence of unusual levels of phosphate (and other nutrients) that had accumulated in the substrate and was released by drought followed by flooding.

Within the blanket of *Spirogyra*, there were embedded stems of sago pondweed and on the surface there was some *Lemna*. Swan broods avoided the open centre of the marsh and foraged exclusively in the channels and openings in the cattail fringe. There, although *Spirogyra* was present, they found enough accessible pondweed and duckweed to satisfy their needs.

The 2017 experience with swans in the Cranberry Marsh area illustrated some of their unfamiliar capabilities. In spring, mature breeders, engaged in territorial defense and reproduction, were, as usual, not mobile. Non-territorial adults, sub-adults and yearlings are normally settled where there are ample food resources, where there is relative freedom from aggression and where they can prepare for moult. In 2017, the availability of unusually nutritious food revealed unexpected abilities of these swans to abandon their usual routine. They exhibited an ability to detect nutritious food, probably by taste, an ability to communicate with others and a willingness to travel considerable distances at a time when they are normally static and preparing to moult.

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