SHOT INGESTION BY WATERFOWL ON NATIONAL WILDLIFE REFUGES IN FLORIDA

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Abstract: Gizzards from 9,632 ducks bagged by hunters on or adjacent to 4 National Wildlife Refuges in Florida from 1973 through 1978 were examined for ingested lead and steel shot. Lead and/or steel shot were found in 197.4% of the 15 species represented. Mean ingestion rates ranged from more than 50% for both canvasbacks (*Aythya valisineria*) and ruddy ducks (*Oxyura jamaicensis*) to less than 10% for lesser scaups (*A. affinis*), green-winged teals (*Anas crecca*), blue-winged teals (*A. discors*), wigeons (*A. americana*), gadwalls (*A. strepera*), shovelers (*A. clypeata*) and fulvous whistling ducks (*Dendrocygna bicolor*). Few differences were found in comparing male to female ingestion rates. Data also are presented on numbers of pellets in gizzards containing ingested shot.

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Lead shot ingestion and resultant lead poisoning was reported in waterfowl prior to the turn of the century (Grinnel 1894) and numerous lead poisoning die-offs of varying magnitude have been reported throughout the United States. Bellrose (1959) summarized the results of examination of over 39,000 gizzards from ducks bagged by North America hunters. His studies suggested that although species susceptibility to ingestion of pellets was highly variable, the annual loss of water fowl from lead poisoning was between 2 and 3% of the population. A more recent compilation of studies relating to lead poisoning and use of non-toxic shot may be found in an environmental statement by the U.S. Fish and Wildlife Service (1976).

Mid-winter waterfowl surveys illustrate the relative importance of National Wildlife Refuge in Florida to wintering ducks. From 1970 to 1978, those survey areas covering refuges contained about 15% of the statewide duck population (Files, Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Washington).

There is little historic information on the incidence of ingested shot in waterfowl in Florida. Bellrose (1959) reported an ingestion rate of 5.8% in 103 gizzards collected from ducks bagged in inland areas of Florida. Stieglitz (1966, 67 and undated) conducted waterfowl food habits studies on several refuges in Florida. He found no shot in 91 duck gizzards from Chassohowitzka National Wildlife Refuge. Shot incidence was not recorded for 123 gizzards collected from Loxahatchee National Wildlife Refuge in 1960-65 but Stieglitz (pers. comm.) indicated the incidence was so low it was not mentioned in his report. An earlier food habits study at Loxahatchee by Valentine (1963) revealed shot in 5 of 20 ring-necked ducks (*A. collaris*). At Merritt Island National Wildlife Refuge Stieglitz (1967) reported that 8.4% of 107 ducks representing 15 species contained ingested shot.

The U.S. Fish and Wildlife Service began a field program to test non-toxic (steel) shot on 7 public hunting areas in the United States in 1972. The program was expanded in 1973 and Merritt Island was 1 of the areas selected. Results from 1973 gizzard collections showed extremely high shot ingestion rates at Merritt Island and the collection areas were increased to include Loxahatchee, Chassahowitzka and J. N. "Ding" Darling National Wildlife Refuges.

This paper reports on the combined ingestion rates of both lead and steel shot from refuges and adjacent areas in Florida.

Refuge personnel and volunteers assisted in data collection and examining gizzards for pellets. During the early phases of the study much of the work was done by L. West, former assistant Refuge Manager at Merritt Island. E. Martin, of the Migratory Bird and

Habitat Research Laboratory, examined over 200 gizzards from the 1975-76 hunting season. We gratefully acknowledge the help of thousands of duck hunters who permitted us to remove gizzards from bagged ducks.

MATERIALS AND METHODS

The study was conducted on 4 National Wildlife Refuges in central and southern Florida during the duck hunting seasons from 1973 to 1978. Merritt Island, Loxahatchee and Chassahowitzka have public hunting programs; J. N. "Ding" Darling is closed to hunting, but duck hunting takes place in surrounding areas.

During the 5 year study on an estimated 31,044 hunter visits at Merritt Island accounted for 67,141 ducks bagged. Loxahatchee had almost as much hunting pressure with 29,142 visits but only 46,877 ducks were bagged. Chassahowitzka, with a smaller area opened to hunting, estimated that 1,933 hunters bagged 3,218 ducks. We have no reliable estimates on hunting adjacent to J. N. "Ding" Darling but due to lower waterfowl populations in southwest Florida hunting pressure is light compared to the other 3 refuges.

Merritt Island hunting areas consist of about 14,170 ha of shallow brackish impoundments and lagoons on the east central Florida coast. Bottoms are firm sand with a flocculent detrital layer up to several inches deep in the impoundments. Common aquatic plants in the impoundments, which are managed for both waterfowl use and mosquito control, include widgeon grass (*Ruppia maritina*), spiny naiad (*Najas marina*) and muskgrass (*Chara sp.*). Dominant vascular plants in the lagoons are manatee grass (*Cymodocea manatorum*) and shoal grass (*Diplanthera wrightii*). Chassahowitzka, on the west coast of Florida, has 1,000 ha of tidal brackish lagoons and marshes open to public hunting. Bottoms consist of mixed sand and marl. Aquatic vegetation is similar to that of Merritt Island. J. N. "Ding" Darling is located on the southwest Florida coast and duck hunting in surrounding areas occurs in tidal, mangrove (*Rhizophora mangle*) lined bays with bottoms ranging from firm sand to soft muck.

Loxahatchee, an inland freshwater marsh in southeast Florida, has a hunting area of about 13,360 ha. The habitat of this refuge is much different from those previously mentioned and waterfowl feed mostly on seeds of emergent plants. Dominant plants include white water lilly (*Nymphaea odorata*), Tracey's beakrush (*Rhynchospora traceyi*), spikerush (*Eleocharis spp.*), sawgrass (*Cladium jamaicensis*), and cattail (*Typha spp.*). Peat deposits in the marshes may reach depths of 3 to 4 m.

Loxahatchee's wintering waterfowl population consists mainly of ring-necked ducks. On the other 3 refuges additional species sampled included: lesser scaup, canvasback, redhead, ruddy duck, pintail, wigeon, shoveler, blue-winged teal, green-winged teal, black duck (*A. rubripes*), mottled duck (*A. fulvigula fulvigula*), mallard (*A. platyrhynchos*), gadwall and fulvous whistling duck.

Gizzards from bagged ducks were collected at refuge check stations or in the field, individually marked with clip-on cloth or paper laundry tapes, and then frozen. They were later examined by U.S. Fish and Wildlife Service personnel and student employees. Gizzard contents were flushed out with a stream of water into a light-colored pan. Care was taken to assure that all shot recorded were ingested. If a non-eroded pellet was found, the gizzard was closely examined for entrance holes which might indicate that it had been fired directly into the gizzard. About 200 mottled duck, black duck and mallard gizzards were fluoroscoped for shot in 1975-76.

A magnet was used to determine if steel shot were present, but in this paper both lead and steel shot were combined. Since this paper is concerned mainly with ingestion rates we made the assumption that ducks ingesting shot would pick up steel as readily as lead.

RESULTS AND DISCUSSION

During 5 duck hunting seasons, 17.4% of 9,632 duck gizzards representing 15 species contained ingested shot. Merritt Island, with a 19.9% ingestion rate, had the highest incidence whereas J. N. "Ding" Darling was lowest with only 3.6% (Table 1). Most of the gizzards examined (77.5%) were from Merritt Island, while only 3.5% were from J. N. "Ding" Darling.

Table 1. Shot ingestion rates in duck gizzards from or near four national wildlife refuges in Florida 1973-78.

Species	Merritt Island		Chassahowitzka		Loxahatchee		J. N. "Ding" Darling		Cumulative	
	No. of gizzards	No. with shot (%)	No. of gizzards	No. with shot (%)	No. of gizzards	No. with shot (%)	No. of gizzards	No. with shot (%)	No. of gizzards	No. with shot (%)
Canvasback	229	153 (66.8)	5	0					234	153 (65.
Ruddy duck	107	59 (55.1)							107	59 (55.
Mallard	35	15 (42.9)	14	1 (7.4)			1	0	50	16 (32.
Redhead	175	53 (30.3)	3	0					178	53 (29.
Mottled duck	419	126 (30.1)			15	3 (21.4)	18	2 (11.1)	452	131 (29.
Black duck	25	7 (28.0)	8	1 (12.5)					33	8 (24.
Pintail	1040	276 (26.5)	88	12 (13.6)	1	1 (100.0)	5	1 (20.0)	1134	290 (25.
Ring-necked duck	2144	725 (33.8)	19	1 (5.3)	1292	102 (7.9)			3455	828 (24.
Scaup	713	26 (3.6)	264	50 (18.9)	3	0	98	6 (5.3)	1078	82 (7.
Green-winged teal	369	5 (1.4)	22	0			56	1 (1.8)	447	6 (1.
Wigeon	831	7 (0.8)	83	7 (8.4)			54	0	968	14 (1.
Blue-winged teal	931	15 (1.6)	3	0	3	0	88	2 (2.3)	1025	17 (1.
Gadwall	71	0	7	1 (14.3)			9	0	87	1 (1.
Shoveler	297	1 (0.3)	1	0	1	0	9	0	308	1 (0.
Fulvous whistling duck	10	0							10	
Unknown	65	17 (26.2)					1	0	66	17 (25.
Total	7461	1485 (19.9)	517	73 (4.1)	1315	106 (8.1)	339	12 (3.6)	9632	1676 (17.

Incidences among species were extremely variable, ranging from a high at Merritt Island of 66.8% in canvasbacks to 9 in gadwalls and fulvous whistling ducks (Table 2). A total of 50% of both canvasbacks and ruddy ducks on all 4 refuges contained ingested shot. Shot ingestion rates of over 20% were found in mallards, redheads, mottled ducks, black ducks, pintails and ring-necked ducks. Ingestion rates of less than 10% were recorded for scaups, green-winged teals, blue-winged teals, wigeons, gadwalls, shovelers, and fulvous whistling ducks (Table 1).

As a group, diving ducks had higher rates than dabblers. Of 5,052 diving duck gizzards examined from all 4 refuges, 1,175 (23.3%) contained ingested shot. However, in the dabbling duck group only 484 (10.7%) of 4,483 gizzards contained ingested shot.

DIVING DUCK INGESTION RATES

Bellrose (1959) reported that ducks in the genus *Aytha* had a higher frequency of ingested shot than any other group or genus of waterfowl. He suggested that this higher incidence was due to the combined effects of feeding in heavily shot-over areas and taking primarily seeds, tubers and rootstocks of aquatic plants as food items. We feel that these observations are also true for this genus in Florida, except for lesser scaups which feed mainly on invertebrates.

The ingestion rate of 65.4% for the 234 canvasbacks examined in our study (Table 1) was particularly alarming in view of the low continental populations in recent years (Bellrose 1976). Another factor indicating the tendency of canvasbacks to ingest shot was the frequent occurrence of large numbers of shot per duck (Table 3). At Merritt Island, where most of the gizzards were collected, more canvasbacks (19.2%) ingested over 10 pellets each than 1 pellet (16.3%). From 1973 to 1976 a hunting closure on canvasbacks and redheads was in effect at Merritt Island, and our sample consisted of birds seized from illegal hunters. In 1976-77 and 1977-78 hunting seasons were open on these species and 207 gizzards were collected. Canvasbacks usually feed in shallow impoundments

Table 2. Shot ingestion rates in duck gizzards from Merritt Island National Wildlife Refuge.

Species	1973-74		1974-75		1975-76		1976-77		1977-78	
	No. exam.	With shot (%)	No. exam.	With shot (%)	No. exam.	With shot (%)	No. exam.	With shot (%)	No. exam.	With shot (%)
Canvasback	4	3 (75.0)	16	12 (75.0)	2	2 (100.0)	165	118 (71.5)	42	18 (42.9)
Ruddy duck	22	17 (77.3)	56	26 (46.2)	9	5 (55.6)	14	8 (57.1)	6	3 (50.0)
Mallard	1	0	2	0	12	5 (41.7)	20	10 (50.0)		
Ring-necked duck	203	110 (54.2)	976	298 (30.5)	632	206 (32.9)	217	78 (35.9)	116	33 (28.4)
Redhead	22	17 (77.3)	24	8 (33.3)	20	8 (40.0)	51	19 (37.3)	58	1 (1.7)
Mottled duck	28	6 (21.4)	109	24 (22.0)	171	63 (36.8)	48	17 (35.4)	63	16 (25.4)
Black duck	4	1 (25.0)	8	1 (12.5)	10	4 (40.0)	3	1 (33.3)		
Pintail	34	14 (41.2)	167	30 (18.0)	423	132 (31.2)	207	67 (32.4)	209	33 (15.8)
Scaup	109	4 (3.7)	283	16 (5.6)	321	6 (1.9)				
Blue-winged teal	73	2 (2.7)	273	9 (3.3)	585	4 (0.7)				
Green-winged teal	41	0	72	1 (1.4)	256	4 (1.6)				
Wigeon	53	0	181	3 (1.6)	597	4 (0.7)				
Shoveler	7	0	68	1 (1.5)	222	0				
Gadwall	4	0	19	0	48	0				
Fulvous whistling duck	2	0			8	0				
Unknown	12	5 (41.7)							53	12 (22.6)
Total	619	179 (28.9)	2254	429 (19.0)	3316	443 (13.4)	725	318 (44.5)	547	116 (21.2)

Table 3. Frequency of number of shot per gizzard at Merritt Island National Wildlife Refuge, 1973-78. Percentages are in parentheses.

Species	Number of Pellets										
	1	2	3	4	5	6	7	8	9	10	> 10
Canvasback	25 (16.3)	22 (14.4)	18 (11.8)	14 (9.2)	13 (8.5)	12 (7.8)	8 (5.2)	4 (2.6)	6 (9.3)	2 (1.3)	29 (19.0)
Ring-necked duck	339 (46.8)	183 (25.2)	85 (11.7)	38 (5.2)	25 (3.4)	11 (1.5)	14 (1.9)	3 (.40)	9 (1.2)	6 (.80)	12 (1.70)
Pintail	141 (51.1)	55 (19.9)	27 (9.8)	8 (2.9)	10 (3.6)	3 (1.1)	2 (0.7)	3 (1.1)	3 (1.1)	3 (1.1)	16 (5.8)
Ruddy duck	22 (37.3)	10 (16.9)	7 (11.9)	3 (5.1)	4 (6.8)	3 (5.1)	2 (3.4)	2 (3.4)	0 (0)	3 (1.1)	16 (5.8)
Redhead	16 (30.2)	7 (13.2)	4 (7.5)	4 (7.5)	2 (3.8)	2 (3.8)	3 (5.7)	2 (3.8)	1 (1.9)	0 (0)	6 (10.2)
Mallard	4 (26.7)	4 (26.7)	4 (26.7)	0	0	0	0	0	0	3 (5.7)	9 (17.0)
Black duck	3 (42.9)	4 (26.7)4 (26.7)								0	3 (20.0)
Black duck	3 (42.9)	0	0	1 (14.3)	0	1 (14.3)	0	1 (14.3)	0	0	1 (14.3)
Mottled duck	53 (42.1)	17 (13.5)	12 (9.5)	7 (5.6)	6 (4.8)	4 (3.2)	3 (2.4)	3 (2.4)	3 (2.4)	1 (0.8)	17 (13.5)
Scaup	22 (84.6)	0	3 (11.5)	0	1 (3.8)	0	0	0	0	0	0
Shoveler	1 (100.0)	0	0	0	0	0	0	0	0	0	0
Wigeon	5 (71.4)	1 (14.3)	1 (14.3)	0	0	0	0	0	0	0	0
Green-winged teal	5 (100.0)	0	0	0	0	0	0	0	0	0	0
Blue-winged teal	12 (80.0)	2 (13.3)	0	0	1 (6.7)	0	0	0	0	0	0
Total	648 (44.1)	301 (20.5)	161 (11.0)	75 (5.1)	60 (4.1)	43 (2.9)	33 (2.2)	17 (1.2)	22 (1.5)	15 (1.0)	93 (6.3)

which are traditional hunting areas and are exposed throughout the winter to spend shot deposited on the firm bottoms. A reduced ingestion rate occurred in canvasbacks as well as some other species in 1977-78, probably because of increased feeding in larger bodies of water where shot was less concentrated. In contrast to our study, Bellrose (1959) found that only 11.8% of 871 canvasback gizzards collected throughout the United States and Canada contained ingested shot. Hunt (1960) reported that less than 4% of the canvasbacks wintering on the Detroit River contained ingested shot.

Ruddy ducks, all of which were collected from Merritt Island, also had extremely high ingestion rates. Fifty-nine (55.1%) of the 107 gizzards examined contained shot (Table 1). This high rate was over 45% for each of the 5 years of the study (Table 2). Ruddy ducks fed in the same areas frequented by canvasbacks and, based on gizzard contents, had similar food habits. Studies by the Florida Game and Freshwater Fish Commission (Hines, unpublished data) revealed a 20% ingestion rate in 20 ruddy ducks bagged during the 1976-77 hunting season in Florida. Reid (1948) reported a 4.5% ingestion rate in Minnesota.

Merritt Island was the collection site for 175 of the 178 redhead gizzards. The mean ingestion rate of 30.3% at Merritt Island was not representative of all years (Table 2). In 1977-78 we found an incidence of only 1.7%. This was probably due to extremely high salinities in the impoundments resulting from low rainfall in the summer. Aquatic

Table 4. Sex difference in shot ingestion rates in duck gizzards from or near four national wildlife refuges in Florida 1973-78.

Species	Sex	Merritt Island		Loxahatchee		Chassahowitzka		J.N. "Ding" Darling	
		Number of gizzards	Number with shot (%)	Number of gizzards	Number with shot (%)	Number of gizzards	Number with shot (%)	Number of gizzards	Number with shot (%)
Ring-necked duck	M	1030	344 (33.4)	444	40 (9.0)				
	F	909	270 (29.7)	848	66 (7.8)				
Scaup	M	237	7 (3.0)			62	11 (17.7)	50	2 (4.2)
	F	367	15 (4.1)			41	6 (14.6)	48	2 (8.3)
Ruddy duck	M	37	17 (45.9)						
	F	48	25 (52.1)						
Redhead	M	54	7 (13.0)						
	F	99	29 (29.3)*						
Canvasback	M	54	38 (70.4)						
	F	171	110 (64.3)						
Pintail	M	648	181 (27.9)			45	10 (22.2)		
	F	358	81 (22.6)			22	7 (31.8)		
Mottled duck	M	218	70 (44.3)						
	F	158	44 (27.8)						
Wigeon	M	456	5 (1.1)			55	6 (10.9)	32	0
	F	322	2 (0.6)			12	0	21	0
Blue-winged teal	M	416	5 (1.2)					58	1 (1.7)
Green-winged teal	M	146	3 (2.1)					40	0
	F	182	2 (2.1)					40	1 (2.5)

*$P < 0.05$, chi-square test.

vegetation was killed or inhibited in many impoundments, and redheads fed almost exclusively on marine grasses in the open expanses of saltwater lagoons where little spent shot was deposited. Bellrose (1959) reported an ingestion rate of 13.6% in redheads, one of the highest rates in his study.

Our largest sample size consisted of ring-necked ducks, the most heavily harvested species in Florida (Carney et. al. 1975). Of 3,455 gizzards examined, 828 (24.0%) contained shot (Table 1). The majority of the gizzards came from Merritt Island and Loxahatchee. Merritt Island's ingestion rate of 33.8% was about 4 times as high as Loxahatchee's 7.9%. As previously mentioned, Loxahatchee has softer bottoms consisting of muck and peat. Hunting practices also are different. Hunters and ducks are less concentrated at Loxahatchee than at Merritt Island and pellets are probably more scattered through the hunting area. Hines (unpublished data) found an overall shot ingestion of 20% for Florida but found a 33% incidence in heavily hunted lakes in northwest Florida. Bellrose (1959) reported that ring-necked ducks had the highest (14.2%) overall ingestion rates nationwide of any species he studied, but in the Atlantic Flyway, ring-necked ducks ranked seventh.

Scaups had the lowest (7.6%) accumulative ingestion rate of any species of diving duck (Table 1). Relatively low rates were encountered at all refuges in all years except for Chassahowitzka in 1977-78. In that season 46 (23.5%) of the 196 gizzards collected contained ingested shot. We can offer no explanation at this time but further monitoring will hopefully shed some light. Unfortunately, scaup gizzards were not collected at Merritt Island for the 1976-77 and 1977-78 hunting seasons since the incidence of shot had been consistently low for this species. Therefore, we cannot compare the 2 refuges in those years. On the refuges studied scaups usually feed offshore in bays and estuaries and normally are not exposed to areas where concentrations of spent shot are deposited. Bellrose (1959) reported a relatively high (13.1%) overall ingestion rate for scaups, but in the Atlantic Flyway he recorded an incidence of only 6.3%. Hines (unpublished data) found that 7% of 153 scaups in Florida contained ingested shot. Scaups have been common in some outbreaks of lead poisoning. In 1972 they comprised 75% of 394 birds in Illinois found dead or dying (Anderson 1975).

DABBLING DUCKS INGESTION RATES

Four species of dabbling ducks, including mallards, mottled ducks, black ducks and pintails had ingestion rates greater than 25% at Merritt Island (Table 1). Except for pintails at Chassahowitzka, sample sizes at the other refuges were too small to draw any conclusions. Of 1,040 pintail gizzards examined at Merritt Island, 276 (26.3%) contained ingested shot compared to 12 (13.6%) at Chassahowitzka. These rates were not as high as those reported for pintails at Sauvie Island, Oregon, by White and Stendell (1977), but were considerably higher than the 15.7% for the Atlantic Flyway average reported by Bellrose (1959.).

Mottled ducks were the only permanent resident waterfowl sampled in the study and their ingestion rates should give a good indication whether spent shot is ingested locally or is picked up elsewhere by migrating ducks. At Merritt Island 126 (30.1%) of 419 gizzards had ingested shot (Table 1). Lower incidents were encountered at other refuges but sample sizes were too small to reveal definite trends. Mottled ducks at Merritt Island feed both in impoundments and along the heavily hunted edges of bays and lagoons where they are exposed to spent shot throughout the year. Although the Merritt Island rates were high, they were much lower than the 43.6% occurrences of lead pellets in mottled duck gizzards at the Murphree Wildlife Management area in Texas (Stutzenbaker 1974). Mottled duck shot ingestion was discussed in an earlier food habits study at Merritt Island by Stieglitz (1967), who reported a 17.5% incidence of lead shot in 40 gizzards.

Mallards (32.0%) and black ducks (24.2%) both had relatively high ingestion rates but sample sizes were too small for drawing any definite conclusions (Table 1).

Green-winged teals, blue-winged teals, wigeons, gadwalls, shovelers and fulvous whistling ducks all had combined incidences of less than 2% for all 4 refuges (Table 1). The only significant deviation from this low figure was the 8.4% (8/23) ingestion rate for wigeons at Chassahowitzka. Observations at Merritt Island indicate that these species normally do not feed extensively on larger seeds in the bottom soils and usually do not "puddle" in one spot for extended periods. They would, therefore, not be expected to ingest large amounts of shot. Wigeons in particular usually feed on the leafy portions or roots of aquatic plants and have little opportunity to ingest shot unless they pick it up incidental to eating grit. Low ingestion rates for greenwinged teals, wigeons, gadwalls and shovelers were also reported by Bellrose (1959).

SEX DIFFERENCES

Differences between male and female ingestion rates are presented in Table 4. The only significant difference ($P < 0.05$) was the higher ingestion rate of female redheads compared to males. White and Stendell (1977) examined male and female mallards, pintails, and black ducks for ingested lead shot and found a significantly higher ($P < 0.05$) proportion of male pintails than females contained ingested shot. Our data also showed a higher ingestion rate for male pintails than females but the difference was not statistically significant.

FREQUENCY OF NUMBER OF PELLETS PER GIZZARD AT MERRITT ISLAND

Table 3 shows the frequency distribution of numbers of shot in pellet-containing gizzards from Merritt Island. Of 1,468 gizzards containing shot, 44.1% contained only 1 pellet each while 12.2% contained more than 6 pellets each and 6.3% contained more than 10 pellets each. Bellrose (1959) found that only 7.4% of the gizzards he examined with ingested shot contained more than 6 pellets each while 64.7% contained 1 pellet each. A more recent study by White and Stendell (1977) revealed that only 4% of the mallards, black ducks, pintails, and Canada geese contained more than 10 shot each.

Bellrose (1959) indicated that pintails, ring-necked ducks and lesser scaups were more likely to have large numbers of shot per gizzard. Our species ranked in descending order as to their likelihood of ingesting more than 6 pellets each were: canvasbacks, ring-

necked ducks, pintails, mottled ducks, redheads, and ruddy ducks (Table 3). One redhead had ingested 98 shot, but this was obviously atypical. No scaup ingested more than 6 shot. This was probably due to their habit of feeding in open expanses of bays where spent shot ws scattered or non-existent. Black duck and mallard sample sizes were too small for reliable conclusions even though they contained relatively large numbers of shot per gizzard.

With the major exception of lesser scaup, ingestion rates at Merritt Island were generally much higher than for most other areas in the United States and canvasbacks, redheads, ruddy ducks and ring-necked ducks were commonly observed with lead poisoning symptoms. Loxahatchee's major wintering species, the ring-necked duck, had a lower ingestion rate than at Merritt Island (7.9% compared to Merritt Island's 33.8%), but this relatively low level might still account for an unacceptable loss of ducks. Sample sizes at both Chassahowitzka and J. N. "Ding" Darling were small comapred to Merritt Island and Loxahatchee and monitoring efforts should be increased, particularly for pintails at Chassahowitzka, so that better comparisons of these refuges can be made. We feel that our ingestion studies to date indicate the use of non-toxic shot is reasonable and justifiable on Florida refuges.

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