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An Economic Evaluation of Selected Treatments for Avian Botulism in Waterfowl on Utah Marshes, 1953-54

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AN ECONOMIC EVALUATION OF SELECTED TREATMENTS FOR AVIAN BOTULISM IN WATERFOWL ON UTAH MARSHES, 1953-54

by

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INTRODUCTION

Purpose and scope

Each year thousands of western waterfowl succumb to disease, predators, mechanical injury and other decimating factors. Based on a review of records it is conservatively estimated that an average of 25,000 ducks have succumbed to botulism on western marsh areas annually.

In a recent study, the United States Fish and Wildlife Service valued each duck and goose at $8.00 (McLeod, 1950). Applying this value to the estimated annual numerical loss, a total of $200,000 has been lost each season in mortality of western waterfowl from botulism. Control of this malady would reduce annual waterfowl and monetary losses.

Prevention and cure are the only means of controlling botulism in wild ducks. At present, no economical preventative measure exists and control is based on curing stricken birds. The prupose of this study was to evaluate the cost of treatment and rate of recovery of birds stricken with botulism when treated by selected methods. The 4 treatments selected for evaluation were: (1) hospital inoculation, (2) fresh water, (3) field inoculation, and (4) no treatment or control. Research included a comprehensive evaluation of factors such as age, sex, species, body condition, degree of affliction, reaction to various amounts of antitoxin, and reaction to selected treatment methods, thought to be pertinent in botulism control. This study was conducted during botulism outbreaks of 1953 and 1954, and was confined to state-owned marshlands of Utah.

Study areas

Three major areas provided sick birds used in this research: (1) Ogden Bay Refuge, (2) Farmington Bay Refuge, and (3) the Public Shooting Grounds. These man-made marsh areas are located on the saline flat lands adjacent to Great Salt Lake.

The majority, 1,979 or 89.3 percent, of sick birds were taken from Ogden Bay Refuge on the Weber River Delta. This state-owned waterfowl refuge contains approximately 13,700 acres of diversified habitat. Excellent conditions for the production and existence of *Clostridium botulinum*, type C, the causative agent of botulism, were apparently present throughout the area.

Farmington Bay Refuge, approximately 20 miles south of Ogden Bay Refuge in Davis County, Utah, was dried for improvements in 1953, but was traversed regularly during the 1954 season. In preparation for the hunting season, water was diverted into the north lake of Farmington Bay on October 1, 1953. A two-man crew picked up and disposed of approximately 2,000 dead ducks from approximately 20 acres of the reflooded marsh on October 6, 1953. This was the most serious outbreak of the study and indicated the rapidity with which sickness advanced. Few sick birds were noted, which indicated that the crisis had passed. Farmington Bay Refuge provided 121 of the 2,214 ducks treated during 1953 and 1954.

Not more than 12 sick or dead birds were seen on the Public Shooting Grounds, 8 miles west of Corinne, Utah, in 1953. During the 1953 season, 3 sick birds were transported from the area to Ogden Bay Refuge for treatment. In 1954 this state-owned shooting area supplied 111 sick birds for treatment.

Other areas were observed during the study but did not provide sick birds for treatment. These areas consisted of: (1) State-owned lands beyond Bear River Migratory Bird Refuge, and (2) Smith and Utah Lakes west of Provo, Utah.

REVIEW OF LITERATURE

Extent of outbreaks

Alkali poisoning or western duck sickness, as botulism was originally known, was first reported among wild ducks around Great Salt Lake, Utah, in 1893. Waterfowl losses, suggestive of botulism, were reported prior to this date but lacked verification. In 1910, losses around Great Salt Lake were of sufficient proportions to attract nation-wide attention (Kalmbach and Gunderson, 1934). Marsh areas adjacent to Great Salt Lake have consistently produced large outbreaks of botulism.

The initial appearance of the epizootic in California occurred in the vicinity of Soleta Lake in 1908. A subsequent outbreak prevailed in this area in 1909 (Clarke, 1913).

Since its debut, botulism has been reported from widely scattered areas in varying intensities. Only two areas outside North America have reported the incidence of botulism. Repeated outbreaks have occurred in the vicinity of Victoria, Australia (Kalmbach, 1935). Evidence of the malady was noted in the vicinity of Laguna Castillos, Uruguay, in 1921 (Kalmbach and Gunderson, 1934). Points of occurrence in North America are indicated on figure 1. Some important outbreaks in North America are listed in table 1.

History of research

Botulism research began with the 1911 outbreak in California. Attention was directed toward the cause of the malady and was centered around a body of stagnant, alkaline water and exposed mud flats of the Tulare Lake area. Results of this beginning project indicated the

Table 1. Waterfowl losses from botulism in North America as recorded in literature

Area	Year	Approximate loss	Reference
Great Salt Lake, Utah	1893	"...thousands..."	Zimmerman, 1946
	1910	200,000-300,000	Zimmerman, 1946
	1912	75,000	Kalmbach and Gunderson, 1934
	1913	46,723[1]	Kalmbach and Gunderson, 1934
	1914	8-10,000[2]	Kalmbach and Gunderson, 1934
	1929	100,000-300,000	Kalmbach and Gunderson, 1934
	1932	65,000-150,000	McLeod, 1950
	1950	20,000	Utah Fish & Game Comm., 1950
	1952	50,000	Nelson, 1952
Buena Vista Lake, Calif.	1913	40,000[3]	Kalmbach and Gunderson, 1934
Tulare Lake, Calif.	1913		Kalmbach and Gunderson, 1934
Lake Malheur, Oregon	1925	100,000	Kalmbach and Gunderson, 1934
Tule Lake, Calif.	1925	25-50,000	Kalmbach and Gunderson, 1934
Chase Lake Bird Refuge, South Dakota	1930	"...large numbers of waterfowl..."	Kalmbach and Gunderson, 1934
Oaks and Sylvan Lakes, Minnesota	1931	"Great numbers of ducks, shore birds and domestic poultry died on mud flats of these areas."	Kalmbach and Gunderson, 1934
Tlahualilo, Mexico	1925	"Many thousands of birds..."	Kalmbach and Gunderson, 1934

1. Picked up only those birds lying in conspicuous places.
2. Picked up in approximately 2 miles of shoreline on the lower channel of Weber River.
3. Combined loss from Buena Vista and Tulare Lake during 1913.

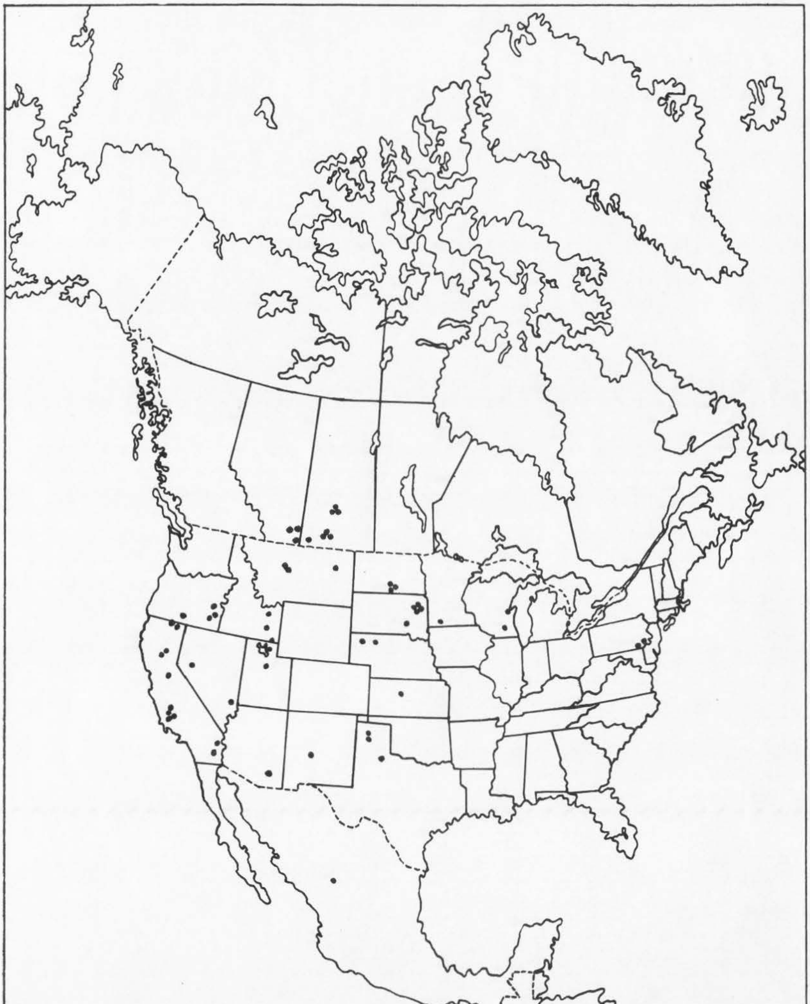


Figure 1. Points of reported incidence of botulism among wild birds in North America

causative organism to be harbored by the water. Many conditions necessary for production of toxin and some characteristic symptoms shown by stricken birds were unveiled during this program (Clarke, 1913).

In 1914 the Bureau of Biological Survey launched its first botulism study around Great Salt Lake, Utah. Findings indicated that "Duck sickness in Utah is caused by the toxic action of certain soluble salts found in alkali" (McLeod, 1950). Giltner and Couch, working under the Bureau in 1930, isolated and identified Clostridium botulinum, type C, from intestinal tracts of stricken birds, thus removing the cause of botulism from chemical texicology and directing it toward bacteriology (Kalmbach and Gunderson, 1934). These workers later proved a definite relationship of this organism to western duck sickness (Kalmbach, 1935). Attempts were made to determine field conditions favorable to toxin production, and the relative suitability of various media was investigated. Research during following seasons was directed toward demonstrating that toxin was produced in the field, and in food likely to be ingested by feeding waterfowl (Kalmbach and Gunderson, 1934). Much of today's research is concerned with these points.

Since discovery of the causative organism, many widespread and diverse studies have been conducted. Some workers revived old theories, others proceeded to supplement previous discoveries concerning Clostridium botulinum, type C. Although numerous requirements of the bacterium have been discovered, many characteristics of the malady continue to baffle biologists.

Various methods were employed to reduce waterfowl losses while research on causes of botulism was progressing. Scaring or luring devices were used to keep ducks from toxic areas (Coburn and Quortrup, 1938).

Disinfectants and water manipulations were designed to reduce losses (Jensen, et al., 1944). The efficiency of treatment methods has been studied. Some treatments were found to be laborious and uneconomical, others seemed to fit the needs of the biologist.

Placing birds in an enclosure with fresh water, clean food and shelter was a pioneer treatment of birds with botulism (Wetmore, 1918). Wetmore conducted a study involving 1,211 ducks of 7 species. These sick birds were treated by placing them in fresh water and in some cases administering caster oil (orally) to soothe irritation. Large species received 2 cc. and smaller ducks 1 cc. of caster oil. Birds with lead poisoning (as determined by autopsy after death) were eliminated from the calculations and a 77 percent recovery was noted. Severely stricken birds showed a low recovery.

A more recent treatment, used extensively during the past 8-10 years, is to treat birds with injections of botulinum antitoxin. Quortrup (1943) injected 175 birds with 2 cc. of botulinum antitoxin and obtained 91.4 percent recovery. A control group of 59 birds receiving no antitoxin was placed in a fresh water area. This group showed a 64.4 percent recovery.

McLeod (1950) cites a program under which birds unable to hold their heads up received shots of antitoxin. Large ducks received 4 cc. of antitoxin and smaller birds, such as teal, received 2 cc. If ducks failed to recover after the first injection and did not die, a second injection was given. A recovery of 70 percent was noted for this treatment.

In a study of treated sick birds from state-owned marshes in Utah, Nelson (1952) reports an 84.6 percent recovery of all birds inoculated with antitoxin and 71.9 percent recovery for those placed in fresh water.

During this 1952 study, a total of 6,887 ducks were treated. This large number of birds greatly reduced the cost of treatment by reducing time and expense involved in capturing sick birds. The cost-per-bird for antitoxin injected ducks was $0.33, and for fresh water treated ducks the cost-per-bird was $0.20.

Recent research by the United States Fish and Wildlife Service at Bear River Refuge, Utah, has concerned the causative organism and its toxic excretory product. Some sick birds have been treated by hospitalization and inoculation with antitoxin during this research, but cost and recovery data are, at present, unavailable. A recent review of botulism research and present status of the disease has been presented by Sciple (1954).

METHODS

Detection of sick birds

During early summer, paralyzed birds were scattered along the shores of study areas. As the number of stricken ducks increased, they moved out into the canals and borrow pits. Some birds could dive; severly afflicted ones could not. When the numbers seen from the dikes were great enough, airboats were launched and reconnaissance was made over the area. Sick birds were recognized by their inability to fly and subsequent "flapping" along the water or by their "squatting" along the shores. Most birds were captured on the open water. Birds along the shore were generally in the poorest condition, as they apparently sought these dry areas as sickness advanced.

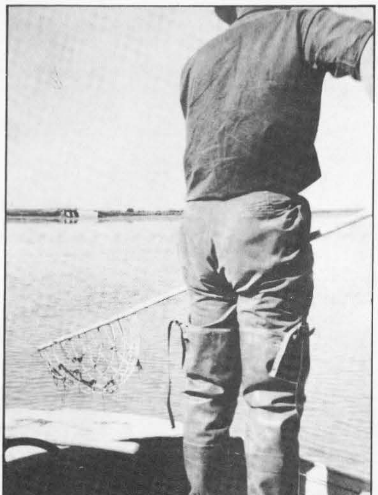
Pick-up of sick ducks

Air-thrust boats and wire hand nets reduced time and effort required for pick-up operations. Airboats, propelled by 65-horsepower aircraft engines, could travel over areas nearly free of surface water. This unique ability increased the volume of pick-up of sick birds. When the number of sick birds was large, movement from one sick bird to the next usually required only a matter of seconds; because of this speed, few birds escaped.

Pick-up nets were constructed, by the writer, of 3/4-inch conduit tubing frames with No. 9 wire nets (figure 4, diagram 1). When approached, a sick bird invariably dived beneath the surface, if capable; capture was usually possible only after the bird resurfaced. However, with pick-up nets most birds could be captured on the first attempt. Wire was used

Figure 2. Airthrust boat used extensively in botulism work during 1953 and 1954

Figure 3. Typical position of a worker preparing to pick up a sick duck



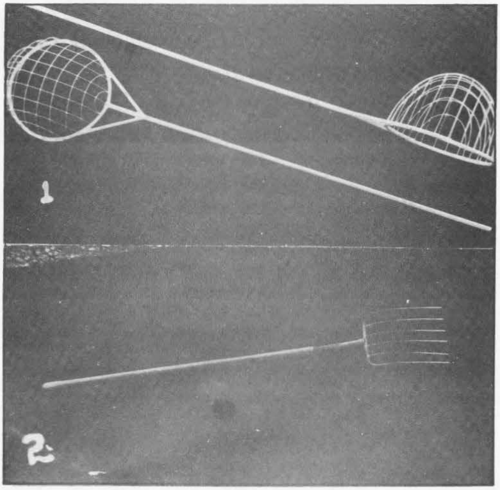


Figure 4. Pick-up nets (1) used to capture sick ducks and a pitchfork (2) used to gather dead birds

on the net after cotton netting proved unsuccessful because of its fouling of the bird. Dead birds were picked up with an ordinary 5-tine pitchfork (figure 4, diagram 2).

Classification of birds

Birds included in this study were classified by species, sex, age, degree of sickness, and body condition. The characters of species, sex, and age were determined by commonly accepted methods. The degree of sickness and body condition are relative classes. Three degrees of sickness as used by Quortrup (1943) were found to fill the needs of the problem: (1) Class I birds were mildly afflicted; able to walk and move along, but flightless. (2) Class II birds were somewhat more paralyzed and were unable to move along when placed on a flat surface. (3) Class III birds were the more severely stricken, prostrate birds (figure 5).

Body condition was also of 3 degrees: (1) skinny, (2) medium, and (3) fat - a classification determined by feeling the breast of the bird. This classification was designed to determine whether body condition of afflicted birds might affect their recovery.

Method of injecting antitoxin

Intraperitoneal injections of antitoxin were made with a 22 cc. calibrated medical syringe with a 1-inch, 20-gauge needle. The specifications of the equipment are not important, but this combination proved very satisfactory. The antitoxin used was a commercial, polyvalent (type A, B, and C) botulinum antitoxin of bovine and equine origin.

Intraperitoneal inoculations were most easily made with the worker in a sitting position. A bird was grasped and placed on its back, across the worker's legs, with its head on the side opposite the person's working hand. By grasping a fold of skin just posterior to the breast bone, a

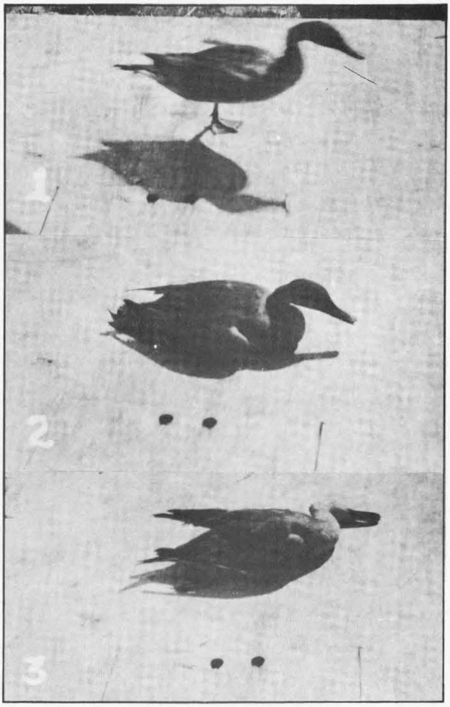


Figure 5. Sick birds typical of class I (1), II (2), and III (3) as classified for purposes of research conducted in 1953 and 1954

suitable base was presented for the injection (figure 6). Care should be taken to place the needle between the folds of skin erected by the fingers and also to avoid puncturing internal organs.

Treatments used

Treatments used in this study were selected on the basis of expected economy and success. The four treatments selected for study were: (1) hospital inoculation, (2) fresh water, (3) field inoculation, and (4) no treatment. These treatments had been used by earlier workers, either partially or entirely, and seemed to warrant critical comparison.

Hospital inoculation treatment. After capture, birds to be included in the hospital inoculation treatment were transported to the hospital site. Before being released in the hospital, birds were banded, recorded, and inoculated with 1 of 3 amounts of antitoxin (2 cc., 1 cc., or 1/2 cc.). Most injections previous to this study had consisted of 2 cc. amounts. Some workers considered this more than was needed for optimum recovery and suggested smaller quantities. Teal, because of their small size, received a maximum dose of 1 cc. of antitoxin. Birds were randomly chosen and segregated into 3 groups for the different quantities of antitoxin. This method of obtaining birds for inoculation served to eliminate bias concerning species, sick class, and/or body condition.

Fresh water treatment. Birds included in the fresh water treatment were picked up in the field and transported to the hospital. Case histories were recorded and each bird was banded for identification. Birds were then released in the hospital enclosure in an effort to determine the effect of protection, and clean, fresh water on their sickness.

Field inoculation treatment. Field inoculated birds received 2 cc.

Figure 6. Technique used in inoculating sick ducks

of antitoxin, with the exception of teal which received 1 cc. As these birds were being inoculated, their case histories were recorded. After inoculation they were banded and released as near their original location as possible. Class III birds were transported to a dry area, preferably an island, to prevent drowning. Frequent observations were made throughout the area to recover any birds dying after treatment. Birds succumbing to the disease could usually be found close to their release site.

No treatment. In conjunction with the field inoculation treatment, an experiment was conducted in which no treatment of birds was involved. These birds were picked up, banded, and their case histories recorded. They were then released as were birds in the field inoculation treatment. Handling was kept at a minimum to determine, as nearly as possible, the recovery rate under natural field conditions. Field treatments were designed in an attempt to determine the extent of a stress factor, if any, produced by handling in transporting to a hospital, and also the effect of antitoxin administered under field conditions.

Hospital construction

In 1952, employees of the Utah State Department of Fish and Game constructed a hospital on Ogden Bay Refuge to be used in botulism research. In 1954, with what appeared to be the beginning of a large, widespread outbreak, hospitals were constructed at Farmington Bay Refuge and on the Public Shooting Grounds.

The hospitals were of temporary construction and consisted of an area enclosed by common chicken wire, 3 feet high. A section of moving, fresh water was included in each enclosure and shade was provided by a grass or willow covered shelter. A plywood enclosure, included on the hospital at Ogden Bay Refuge, was designed as a modified field laboratory.

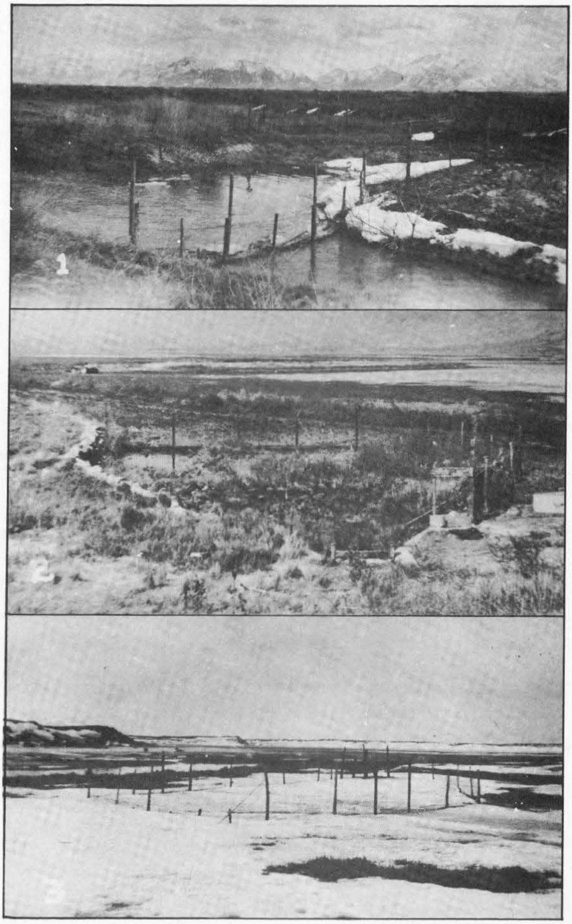


Figure 7. Hospital enclosures as constructed at Ogden Bay Refuge (1), Farmington Bay Refuge (2), and the Public Shooting Grounds (3) - note structure used as a field laboratory at extreme right of diagram 1

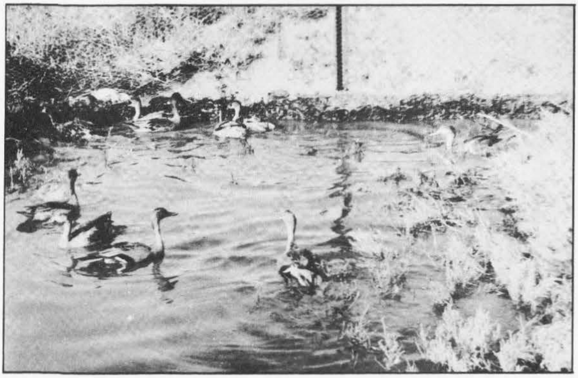


Figure 8. Hospital treated ducks utilizing a pond within the hospital enclosure

Because of limited use, this structure was deemed unnecessary for hospitals at Farmington Bay Refuge and the Public Shooting Grounds.

Equipment used

Little equipment was required for this study. Part of the equipment and material was used only in hospital construction, and consisted of construction materials and tools. Other equipment, used mainly in the pick-up and treatment phase, was as follows:

1. pickup trucks
2. air-thrust boats (gas and oil)
3. pitchforks and specially constructed pick-up nets
4. antitoxin, syringes and antiseptic materials
5. portable cooler and canned ice
6. banding equipment
7. record sheets and datum boards
8. garbage cans (20 gal.)
9. holding crates

Determination of recovery of birds after treatment

The percent recovery of birds included in each method was determined by comparing the number of bands found on birds dying after treatment and the total number banded. In the hospital treatments, the gathering of dead birds was relatively easy and resulted in an accurate count. However, some suspicion was placed on the return from birds dying after being treated in the field. Observations revealed that after release, field treated birds retreated to the nearest available cover.

To test the validity of the data being collected on field-treated birds, 3 methods were employed. (1) Occasional reconnaissance, by persons on foot, was made of vegetated areas to find birds succumbing in these areas. (2) A comparison was made of the number of band returns from birds of the various treatments shot during the hunting season. (3) Statistical checks were run on the numbers found dead after treatment and the hunting return by means of the "chi-square" method of analysis to determine the relationship of these figures. The level of significance was placed at 5 percent for these analyses.

Calculations for cost of treatment

The figures in this manuscript designating the cost-per-bird were calculated from data collected throughout this study. Items involving cost of equipment or material were treated to yield cost-per-bird.

Items involving time were divided proportionately between treatments. Time required for various phases of operation was calculated on a man-minute basis. Some operations involved the services of 2, 3 or 4 men receiving various salaries. The time required of each man was multiplied by his salary and divided by the number of birds involved. Individual figures were subsequently added to give the total cost-per-bird of that particular operation.

Costs or depreciation of permanent equipment are not considered except as depreciation required repairs involving costs or time. Hospital construction materials and time are divided by 5 on the premise that these structures will serve approximately 5 years and costs should be distributed proportionately. The resulting figure was multiplied by 2 for the 1953 and 1954 research. Hospital repair is included as a total because it is required each season (appendix table 3).

The cost-per-bird and recovery rate of each treatment were combined to yield the cost-per-recovered-bird (appendix table 4). By this action the relative economics of the treatments could be determined by comparing one figure.

RESULTS

Botulism outbreaks occurring in Utah during 1953 and 1954 were extremely mild. In 1953, pick-up of sick birds did not begin until August 24. In 1954, no attempt to treat birds was made until August 16. There were 1,710 birds treated in 1953 and 504 in 1954. In contrast, during the 1952 outbreak, operations were begun about August 1, and 6,887 birds were treated (Nelson, 1952). The sharp decline in number of stricken birds over this 3-year period is not fully understood. However, both 1953 and 1954 were seasons of low water levels, which could have caused various reactions harmful to toxin production.

Although numbers of waterfowl treated in 1953 and 1954 were small, it was determined that they were sufficient to be statistically valid. In some groups of birds, however, the expected numbers, when using the "chi-square" method of analysis, were below 5 and considered unreliable for comparison.

Evaluation of recovery from treatments

A total of 994 ducks, 861 treated in 1953 and 133 in 1954, were included in the hospital inoculation treatment. To determine the effects of different sized doses of antitoxin on recovery, these birds were divided into 3 unequal subgroups receiving 2 cc., 1 cc., and 1/2 cc. respectively, of botulinum antitoxin.

Recovery from the 3 dosage groups did not vary appreciably for class I and II birds, but class III birds seemed dependent on amount of antitoxin administered. Class III birds showed a 54.5 percent recovery with 2 cc., 42.7 percent with 1 cc., and 28.6 percent with 1/2 cc. of antitoxin (table 2). Teal, which received 1 cc. and 1/2 cc. injections, showed their highest recovery, 68.8 percent when considering class II and III birds only, when inoculated with 1/2 cc. of antitoxin.

Table 2. Percent recovery of birds hospitalized and injected with selected amounts of antitoxin

Sick class	Amount of antitoxin		
	2 cc.	1 cc.	1/2 cc.
I	97.4%	95.2%	98.6%
II	83.6	82.0	80.4
III	54.5	42.7	28.6
Weighted average	92.1%	88.7%	91.7%

Recovery of sick birds from the fresh water treatment was a comparatively low 82.7 percent. Both the field inoculation and no treatment groups produced high recovery rates. The 95.5 percent recovery following field inoculation was highest of the 4 methods employed. Class I birds showed a high recovery regardless of treatment. However, these mildly stricken birds had their highest recovery, 99.6 percent, under field inoculation and no treatment groups (table 3).

Table 3. Percent recovery from fresh water, field inoculation, and no treatment groups

Sick class	Fresh Water	Field inoculation	No treatment
I	93.9%	99.6%	99.6%
II	59.2	85.7	64.3
III	11.8	22.2	20.0
Weighted average	82.7%	95.5%	94.8%

Greater costs required by the inoculation treatment suggests that class I birds should be left unmolested in the field. Determination of the most economical treatment for class II and III birds is dependent on the costs involved.

Complete recovery data is given in appendix tables 1 and 2.

Evaluation of costs of treatments

Cost-per-treated-bird. The cost of treating birds was high during this study. A low incidence of botulism and the consequent difficulty in obtaining sick birds increased time and operational expenditures. The cost-per-treated-bird for each treatment is given in table 4.

Table 4. Cost-per-treated-bird in 1953 and 1954

Item	Hospital inoculation			Fresh water	Field inoculation	No treatment
	2 cc.	1 cc.	1/2 cc.			
Cost	$0.69	$0.64	$0.61	$0.57	$0.64	$0.53

This listing shows that the control group (no treatment) was most inexpensive. Under ordinary conditions, where banding was eliminated, there would be no expense for this group of birds.

Cost-per-recovered-bird. To aid in economically evaluating treatments, the cost-per-recovered-bird was determined. This cost was derived by use of the following formula:

$$\frac{\text{Total number of birds treated X Cost-per treated-bird}}{\text{Total number of birds recovering after treatment}}$$

The results of these caluclations are given in table 5.

Table 5. Cost-per-recovered-bird in 1953 and 1954

Sick class	Hospital inoculation			Fresh water	Field inoculation	No Treatment
	2 cc.	1 cc.	1/2 cc.			
I	$0.71	$0.67	$0.62	$0.61	$0.64	$0.53
II	0.83	0.78	0.76	0.96	0.75	0.82
III	1.27	1.51	2.14	4.84	2.88	2.65
Wtd. avg.	0.75	0.72	0.67	0.69	0.69	0.56

Because of a high recovery rate and lack of costs, class I birds may most economically be left untreated in the field. Class II and III birds, however, remain as groups which may be helped by treatment. Class I birds were therefore not considered in further evaluation of treatments.

Field inoculation was the most economical treatment for class II birds, costing $0.75. For class III birds, hospital inoculation with 2 cc. of antitoxin was most economical at a cost-per-recovered-bird of $1.27 (table 5).

Separation of class II and III birds, as observed in the field, is at times difficult. Use of different treatments for these 2 sick classes would also present complications. To overcome these difficulties, classes II and III were grouped to present a single cost-per-recovered-bird used in comparing treatments. The results of this grouping showed field inoculation to be most economical costing $0.86 per-recovered-bird (table 6).

Table 6. Cost-per-recovered-bird for sick classes II and III combined

Item	Hospital inoculation			Fresh water	Field inoculation	No Treatment
	2 cc.	1 cc.	1/2 cc.			
Cost	$0.90	$0.91	$0.87	$1.17	$0.86	$0.92

All field inoculated birds with the exception of teal, received 2 cc. of antitoxin. In analyzing the hospital inoculation treatment results (table 6), it was found that birds which received 1/2 cc. of antitoxin showed the most economical recovery. However, by viewing table 7, it was found that 2 cc. injections produced an approximate 7 percent greater recovery than the 1/2 cc. dosage. This difference in rate of recovery seems to warrant the $0.03 per-bird added expense.

Table 7. Percent recovery for classes II and III combined

Item	Hospital inoculation			Fresh water	Field inoculation	No treatment
	2 cc.	1 cc.	1/2 cc			
Recovery	76.8%	70.1%	70.0%	48.7%	74.5%	57.6%

It was previously determined that if banding were eliminated from the no treatment or control group, there would be no cost involved. By eliminating all costs and retaining the combined recovery rate of 57.6 percent for class II and III birds (table 7), no treatment would be most economical of the 4 groups studied. However, the 16.9 percent difference in recovery between not treating and field inoculation indicates that the cost of field inoculation was feasible expenditure. A limited number of severely stricken birds included as the no treatment group in 1953 and 1954 makes any conclusion questionable.

Other significant findings

Recovery in relation to species. Overall, Shoveller ducks (*Spatula clypeata*) had the highest recovery, 91.9 percent, after treatment. Baldpate (*Mareca americana*), Green-winged Teal (*Anas crecca carolinensis*), and Pintail (*Anas acuta tzitzihoa*) followed in percent recovery. Baldpate showed a 91.4 percent recovery; Green-winged Teal and Pintail both had 90.1 percent recovery (appendix table 6).

Wetmore (1918) and others, indicate that Green-winged Teal showed the least resistance to botulism and had low recovery after treatment. Relative susceptibility of a species is difficult to determine because of differential migration of species and consequent fluctuating numbers of each species present in the toxin area.

The 3 species of teal treated, Green-winged Teal, Cinnamon Teal (*Anas c. cyanoptera*), and Blue-winged Teal (*Anas discors*), showed the greatest recovery where handling was minimized. The 2 species of diving ducks which were treated, Ruddy (*Oxyura jamaicensis rubida*) and Redhead (*Aythya americana*), both showed low recovery rates. Appendix table 6 gives a complete listing of recovery by species.

Recovery in relation to sex. Males of all species combined had a slight but significant margin of recovery over females. Males showed a 90.0 percent and females 88.9 percent recovery. Complete recovery data by sex is included in appendix table 7.

Recovery in relation to age. Adult birds showed a 90.2 percent recovery and juveniles 88.2 percent. By comparing the number of adult and juvenile birds stricken with botulism during 1953 and 1954, adults would appear to be more susceptible. However, the number of individuals stricken from each age class may be dependent on relative numbers of the age class present and not on a difference in susceptibility. Appendix table 7 provides age-recovery data.

Recovery in relation to body condition. Class I birds classified as skinny had a greater recovery than birds classified as fat. Class II and III birds, however, showed their greatest recovery in the 'fat' condition.

In both the fresh water and no treatment groups, birds classified as medium showed the greatest recovery (appendix table 8). The inconsistency in recovery in relation to body condition indicates that recovery is not especially dependent on body condition. Body condition is evidently not a true index of a birds affliction as it is in many other diseases.

MANAGEMENT RECOMMENDATIONS

During 1953 and 1954 botulism was extremely mild among waterfowl on Utah marshes. With such small outbreaks, ducks were mildly afflicted and only a small number advanced to the prostrate or class III stage. Few severely stricken birds were obtained for this study and it is recommended that further research be conducted on class II and III ducks.

Class I birds had a high recovery rate regardless of treatment. It is recommended that such mildly stricken birds be left unmolested in the field.

Class II and III birds combined showed their highest recovery, 74.5 percent, under the field inoculation treatment. The combined cost-per-recovered-bird for these classes under the field inoculation treatment was $0.86. It is recommended in future outbreaks, involving large numbers of birds, that the field inoculation treatment be used. It is further recommended that all birds except teal receive 2 cc. of polyvalent botulinum antitoxin. Teal should be given 1/2 cc. injections of antitoxin. In event of small outbreaks such as those of 1953 and 1954, no attempt should be made to treat birds.

Although under normal conditions, leaving birds unmolested in the field (no treatment) would cost nothing and would yield a relatively high recovery, this is not recommended for large numbers of severely stricken birds. However, choice of treatments to be used for large outbreaks may depend on whether the expected difference in recovery, 16.9 percent, from leaving birds unmolested in the field and field inoculation would warrant the expense of inoculating. The importance of this difference will depend on the number of birds stricken. The larger the number stricken, the more important the 16.9 percent.

SUMMARY

1. To aid in economically curing ducks stricken with botulism, 4 treatments previously used against the disease were chosen for a comparative study of relative economy and effectiveness.
2. Treatments chosen for this study were hospital inoculation, fresh water, field inoculation, and no treatment or control. Birds in the inoculation treatments received measured doses of a polyvalent botulinum antitoxin. Recovery of ducks included in fresh water and no treatment was dependent on natural dissipation of ingested toxin. Hospital and fresh water treated birds were placed in an enclosure, others were left in the field.
3. Research began with the advent of sickness in 1953 and was concluded at the end of the 1954 botulism season. Operations were conducted on state-owned waterfowl areas of Utah. Research was confined to areas having the greatest numbers of afflicted ducks; namely, Farmington Bay and Ogden Bay Refuges and the Public Shooting Grounds.
4. Birds were classified according to species, sex, age, degree of sickness and body condition. Degree of affliction and body condition were relative measures determined by the workers. Birds were grouped into 3 sick classes; I, II, and III. Class I birds were mildly sick and class III individuals were prostrate and unable to hold their heads up. Class II was an intermediate degree.
5. Skinny, medium, and fat were the body condition classes used. These classes were determined by manual observation of each bird. Body

condition seemed to have little effect on recovery.

6. Pick-up operations were facilitated by airthrust boats and wire pick-up nets. Sick birds were placed in holding crates until treated. Dead birds were picked up and later burned and buried. A total of 2214 birds were treated during the 2 seasons research. Recovery was dependent on the treatment used. The field inoculation treatment was found to return the most economical recovery.

7. Recovery from each treatment was determined by subtracting the number of birds found dead after treatment from the total treated by that specific method. Birds treated by the field methods were thought to be dying in dense vegetation and not detected. Three methods were devised to check this premise: (1) Frequent reconnaissance of vegetated areas in search of dead birds, (2) comparison of the number of dead birds found after treatment and the bands returned from ducks shot during the hunting season for each treatment, and (3) data were analyzed by use of "chi-square" to determine significance. No significant difference was found between the hunting return and the recovery of birds dying after treatment which indicated that either figure was valid in determining recovery.

8. Field inoculation, which was found to be most economical of the 4 methods, cost $0.64 per-treated-bird during this research, and is recommended for future use. Other treatments varied from $0.53 in the fresh water treatment to a high of $0.69 per-treated-bird for hospital inoculation with 2 cc. of antitoxin. Included in costs were such items as labor, construction materials, antitoxin, repair of equipment, and petroleum products.

9. Different antitoxin doses were included in an attempt to determine the relative effect of smaller doses (2 cc. had been used in most

previous treatments). Doses used consisted of 2 cc., 1 cc., and 1/2 cc. amounts and were administered by intraperitoneal injections.

10. Management recommendations included the prescribed use of the field inoculation treatment. The 2 cc. injection was the most economical for use on larger species of ducks and 1/2 cc. injections were recommended for teal. Because of a shock or stress factor from handling, greater numbers of class I birds were saved if left unmolested in the field. It was recommended that these birds be omitted and that only class II and III birds be treated.

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APPENDIX

Table 1. Number and percent recovery for various amounts of antitoxin as administered to hospital inoculated ducks.

Year	Sick Class	Amount of antitoxin											
		2 cc.			1 cc.			1/2 cc.					
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%
1953	I	236	231	97.9	212	201	94.8	187	185	98.9	635	617	97.2
	II	66	54	81.8	54	46	85.2	50	40	80.0	170	140	82.4
	III	19	11	57.9	24	9	37.5	13	3	23.1	56	23	41.1
	Total	321	296	92.2	290	256	88.3	250	228	91.2	861	780	90.8
1954	I	38	36	94.7	36	35	97.2	33	32	96.1	107	103	96.3
	II	7	7	100.0	7	4	57.1	6	5	83.3	20	16	80.0
	III	3	1	33.3	2	2	100.0	1	1	100.0	6	4	66.7
	Total	48	44	91.7	45	41	91.1	40	38	95.0	133	123	91.7
Total	I	274	267	97.4	248	236	95.2	220	217	98.6	742	720	95.7
	II	73	61	83.6	61	50	82.0	56	45	80.4	190	156	82.1
	III	22	12	54.5	26	11	42.7	14	4	28.6	62	27	43.5
	Total	369	340	92.1	335	297	88.7	290	266	91.7	994	903	90.8

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment - these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 2. Number of birds treated by each method and number and percent recovering after treatment

Year	Sick class	Treatment												Total		
		Hospital						Field								
		Inoculation			Fresh water			Inoculation			No treatment					
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%	T	R	%
1953	I	635	617	97.2	367	345	94.0	147	146	99.3	146	145	99.3	1295	1253	96.8
	II	170	140	82.4	96	53	55.2	29	23	79.3	23	15	65.2	318	231	72.6
	III	56	23	41.1	32	4	12.5	6	2	33.3	3	0	00.0	97	29	29.9
	Total	861	780	90.8	495	402	81.2	182	171	94.0	172	160	93.0	1710	1513	88.5
1954	I	107	103	97.1	97	91	93.8	114	114	100.0	111	111	100.0	429	419	97.7
	II	20	16	80.0	24	18	75.0	13	13	100.0	5	3	60.0	62	50	80.6
	III	6	4	66.7	2	0	00.0	3	0	00.0	2	1	50.0	13	5	38.5
	Total	133	123	92.5	123	109	88.6	130	127	97.7	118	115	97.5	504	474	94.0
Total	I	742	720	95.6	464	436	93.9	261	260	99.6	257	256	99.6	1724	1672	97.0
	II	190	156	82.1	120	71	59.2	42	36	85.7	28	18	64.3	380	281	73.9
	III	62	27	43.5	34	4	11.8	9	2	22.2	5	1	20.0	110	34	30.9
	Total	994	903	90.8	618	511	82.7	312	298	95.5	290	275	94.8	2214	1987	89.7

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment - these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 3. Expenditures, on a per-treated-bird basis, for labor and material used in botulism research during 1953 and 1954

Expenditure	Treatment					
	Hospital				Field	
	Inoculation					No
	Amount of antitoxin			Fresh	Inocu-	treat-
	2 cc.	1 cc.	1/2 cc.	water	lation	ment
Travel						
Salary	$0.161	$0.161	$0.161	$0.161	$0.161	$0.161
Mileage	0.030	0.030	0.030	0.030	0.028	0.028
Antitoxin	0.110	0.055	0.028	0.000	0.110	0.000
Const. of equip.	0.022	0.022	0.022	0.022	0.022	0.022
Hospital const.						
Salary	0.010	0.010	0.010	0.010	0.000	0.000
Material	0.012	0.012	0.012	0.012	0.000	0.000
Checking ducks in hospital (salary)	0.010	0.010	0.010	0.010	0.000	0.000
Airboat						
Gas	0.032	0.032	0.032	0.032	0.047	0.047
Oil	0.003	0.003	0.003	0.003	0.004	0.004
Service (salary)	0.041	0.041	0.041	0.041	0.041	0.041
Repair[1]	0.032	0.032	0.032	0.032	0.032	0.032
Pick-up of ducks (salary)	0.164	0.164	0.164	0.164	0.164	0.164
Recording ducks (salary)	0.008	0.008	0.008	0.008	0.008	0.008
Banding ducks (salary)	0.020	0.020	0.020	0.020	0.000[2]	0.000[2]
Inoculating ducks (salary)	0.015	0.015	0.015	0.000	0.000[2]	0.000
Miscellaneous[3]	0.022	0.022	0.022	0.022	0.022	0.022
Total[4]	$0.69	$0.64	$0.61	$0.57	$0.64	$0.53

1. Includes repair of airboat trailers.
2. These items were being accomplished during the pick-up operations and are included in that cost.
3. Items included in this category were garbage cans, alcohol, funnels, gas pumps, gas drums, oil can spouts, flying service, and hardware.
4. Totals are rounded to the nearest cent - other costs carried to 3 places for accuracy.

Table 4. Cost-per-recovered-bird for treatments used on birds with botulism in 1953 and 1954

Sick class	Hospital treatments												Fresh water			
	Inoculation															
	Amount of antitoxin															
	2 cc.				1 cc.				1/2 cc.							
	T[1]	R[2]	C[3]	CR[4]	T	R	C	CR	T	R	C	CR	T	R	C	CR
I	274	267	$0.69	$0.71	248	236	$0.64	$0.67	220	217	$0.61	$0.62	464	436	$0.57	$0.61
II	73	61	0.69	0.83	61	50	0.64	0.78	56	45	0.61	0.76	120	71	0.57	0.96
III	22	12	0.69	1.27	26	11	0.64	1.51	14	4	0.61	2.14	34	4	0.57	4.84
Total	369	340	$0.69	$0.75	335	297	$0.64	$0.72	290	266	$0.61	$0.67	618	511	$0.57	$0.69

Sick class	Field treatment							
	Inoculation				No treatment			
	T	R	C	CR	T	R	C	CR
I	261	260	$0.64	$0.64	257	256	$0.53	$0.53
II	42	36	0.64	0.75	28	18	0.53	0.82
III	9	2	0.64	2.88	5	1	0.53	2.65
Total	312	298	$0.64	$0.67	290	275	$0.53	$0.56

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment - these birds were assumed to have recovered.
3. Designates the total cost-per-treated-bird.
4. Designates the total cost-per-recovered-bird.

Table 5. Number of treated birds with the number and percent of first-year band returns from the hunting season

Year	Sick class	Treatment																			Total		
		Hospital									Field												
		Amount of antitoxin									Fresh water			Inoculation			No treatment						
		2 cc.			1 cc.			1/2 cc.															
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%		T	R	%
1953	I	236	18	7.6	212	8	3.8	187	11	5.9	367	44	12.0	147	9	6.1	146	12	8.3		1295	102	7.9
	II	66	3	4.5	54	1	1.9	50	1	2.0	96	2	2.1	29	2	6.9	23	1	4.3		318	10	3.1
	III	19	1	5.3	24	0	0.0	13	0	0.0	32	0	0.0	6	1	16.7	3	0	0.0		97	2	2.1
	Total	321	22	6.9	290	9	3.1	250	12	4.8	495	46	9.3	182	12	6.6	172	13	7.6		1710	114	6.7
1954	I	38	1	2.6	36	0	0.0	33	1	3.0	97	1	1.0	114	3	2.6	111	3	2.7		429	9	2.1
	II	7	0	0.0	7	0	0.0	6	0	0.0	24	0	0.0	13	0	0.0	5	0	0.0		62	0	0.0
	III	3	0	0.0	2	0	0.0	1	0	0.0	2	0	0.0	3	0	0.0	2	0	0.0		13	0	0.0
	Total	48	1	2.1	45	0	0.0	40	1	2.5	123	1	0.8	130	3	2.3	118	3	2.5		504	9	1.8
Total	I	274	19	6.9	248	8	3.2	220	12	5.5	464	45	9.7	261	12	4.6	257	15	5.9		1724	111	6.4
	II	73	3	4.1	61	1	1.6	56	1	1.8	120	2	1.7	42	2	4.8	28	1	3.6		380	10	2.6
	III	22	1	4.5	26	0	0.0	14	0	0.0	34	0	0.0	9	1	11.1	5	0	0.0		110	2	1.8
	Total	369	23	6.2	335	9	2.7	290	13	4.5	618	47	7.6	312	15	4.8	290	16	5.5		2214	123	5.6

1. Designates the total number of birds treated.
2. Designates the number of first-year band returns from treated birds shot during the hunting season. All of the 1954 returns were not in for this manuscript.
3. Designates the percent of first-year band returns from treated birds shot during the hunting season.

Table 6. Recovery of ducks, by species, from treatments for botulism used in 1953 and 1954

Species	Treatment																			Total		
	Hospital												Field									
	Inoculation									Fresh water			Inoculation			No treatment						
	Amount of antitoxin																					
	2 cc.			1 cc.			1/2 cc.															
	T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%		T	R	%
Pintail	192	178	87.5	203	186	91.6	277	260	93.9	440	359	81.6	192	185	96.4	189	177	93.7		1493	1345	90.1
Mallard	3	3	100.0	9	7	77.8	14	12	85.7	10	8	80.0	5	5	100.0	3	3	100.0		44	38	86.4
Green-winged Teal	0	0	00.0	51	44	86.3	40	35	87.5	57	52	91.2	33	30	90.9	31	30	96.8		212	191	90.1
Baldpate	7	7	100.0	7	7	100.0	13	13	100.0	31	25	80.6	33	30	90.9	25	24	96.0		116	106	91.4
Shoveller	38	35	92.1	40	37	92.5	52	47	90.4	63	55	87.3	35	34	97.1	32	31	96.9		260	239	91.9
Cinnamon Teal	0	0	00.0	9	7	77.8	5	3	60.0	5	4	80.0	3	3	100.0	2	2	100.0		24	19	79.2
Blue-winged Teal	0	0	00.0	6	2	33.3	3	3	100.0	3	3	100.0	0	0	00.0	1	1	100.0		13	9	69.2
Gadwall	2	2	100.0	4	3	75.0	9	6	66.7	7	4	57.1	8	8	100.0	5	5	100.0		35	28	80.0
Redhead	0	0	00.0	4	3	75.0	3	1	33.3	0	0	00.0	3	3	100.0	2	2	100.0		12	9	75.0
Ruddy	0	0	00.0	2	1	50.0	1	1	100.0	2	1	50.0	0	0	00.0	0	0	00.0		5	3	60.0
Total	290	266	91.7	335	297	88.7	369	340	92.1	618	511	82.7	312	298	95.5	290	275	94.8		2214	1987	89.7

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment - these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 7. Recovery of birds after treatment for botulism in relation to age and sex, as recorded in 1953 and 1954

Year	Sick Class	Hospital treatment																							
		Inoculation												Fresh water											
		Adult male			Juvenile male			Adult female			Juvenile female			Adult male			Juvenile male			Adult female			Juvenile female		
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%
1953	I	468	454	97.0	55	55	100.0	62	61	98.4	50	47	94.0	269	255	94.8	34	29	85.3	39	37	94.9	25	24	96.0
	II	113	96	85.0	22	17	77.3	22	14	63.6	13	13	100.0	71	39	54.9	7	3	42.9	10	7	70.0	8	4	50.0
	III	43	20	46.5	6	2	33.3	5	1	20.0	2	0	00.0	23	3	13.0	3	0	00.0	6	1	16.7	0	0	00.0
	Total	624	570	91.3	83	74	89.2	89	76	85.4	65	60	92.3	363	297	81.8	44	32	72.7	55	45	81.8	33	28	84.8
1954	I	81	79	97.5	5	4	80.0	9	8	88.9	12	12	100.0	72	71	98.6	9	9	100.0	9	7	77.8	7	6	85.7
	II	15	13	86.7	2	1	50.0	2	2	100.0	1	0	00.0	17	12	70.6	3	2	66.7	3	3	100.0	1	1	100.0
	III	5	3	60.0	0	0	00.0	0	0	00.0	1	1	100.0	2	0	00.0	0	0	00.0	0	0	00.0	0	0	00.0
	Total	101	95	94.1	7	5	71.4	11	10	90.9	14	13	92.9	91	83	91.2	12	11	91.7	12	10	83.3	8	7	87.5
Total	I	549	533	97.1	60	59	98.3	71	69	97.2	62	59	96.2	341	326	95.6	43	38	88.4	48	44	91.7	32	30	93.8
	II	128	109	85.2	24	18	75.0	24	16	66.7	14	13	92.9	88	51	58.0	10	5	50.0	13	10	76.9	9	5	55.6
	III	48	23	47.9	6	2	33.3	5	1	20.0	3	1	33.3	25	3	12.0	3	0	00.0	6	1	16.7	0	0	00.0
	Total	725	665	91.7	90	79	87.8	100	86	86.0	79	73	92.4	454	380	83.7	56	43	76.8	67	55	82.1	41	35	85.4

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment - these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 7. Continued

Year	Sick Class	Field treatments																							
		Inoculation												Fresh water											
		Adult male			Juvenile male			Adult female			Juvenile female			Adult male			Juvenile male			Adult female			Juvenile female		
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%
1953	I	114	114	100.0	10	9	90.0	14	14	100.0	9	9	100.0	114	114	100.0	11	11	100.0	13	12	92.3	8	8	100.0
	II	20	15	75.0	4	3	75.0	4	4	100.0	1	1	100.0	12	8	66.7	3	2	66.7	7	5	71.4	1	0	00.0
	III	3	1	33.3	1	0	00.0	1	0	00.0	1	1	100.0	1	0	00.0	1	0	00.0	1	0	00.0	0	0	00.0
	Total	137	130	94.9	15	12	80.0	19	18	94.7	11	11	100.0	127	122	96.1	15	13	86.7	21	17	81.0	9	8	88.9
1954	I	74	74	100.0	16	16	100.0	15	15	100.0	12	12	100.0	72	72	100.0	12	12	100.0	15	15	100.0	12	12	100.0
	II	7	7	100.0	0	0	00.0	2	2	100.0	0	0	00.0	4	3	75.0	1	1	100.0	0	0	00.0	1	0	00.0
	III	3	0	00.0	0	0	00.0	0	0	00.0	0	0	00.0	0	0	00.0	2	1	50.0	0	0	00.0	0	0	00.0
	Total	84	81	96.4	16	16	100.0	17	17	100.0	12	12	100.0	76	75	98.7	15	14	93.3	15	15	100.0	13	12	92.3
Total	I	188	188	100.0	26	25	96.2	29	29	100.0	21	21	100.0	186	186	100.0	23	23	100.0	28	27	96.4	20	20	100.0
	II	27	22	81.5	4	3	75.0	6	6	100.0	1	1	100.0	16	11	68.8	4	3	75.0	7	5	71.4	2	0	00.0
	III	6	1	16.7	1	0	00.0	1	0	00.0	1	1	100.0	1	0	00.0	3	1	33.3	1	0	00.0	0	0	00.0
	Total	221	211	95.5	31	28	90.3	36	35	97.2	23	23	100.0	203	197	97.0	30	27	90.0	36	32	88.9	22	20	90.9

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment - these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 7. Continued-

Year	Sick class	Total											
		Adult male			Juvenile male			Adult female			Juvenile female		
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%
1953	I	965	937	97.1	110	104	94.5	128	124	96.9	92	88	95.7
	II	216	158	73.1	36	25	69.4	43	30	69.8	23	18	78.3
	III	70	24	34.3	11	2	18.9	13	2	15.4	3	1	33.3
	Total	1251	1119	89.4	157	131	83.4	184	156	84.8	118	107	90.7
1954	I	299	296	99.0	42	41	97.6	48	45	93.8	43	42	97.7
	II	43	35	81.4	6	4	66.7	7	7	100.0	3	1	33.3
	III	10	3	30.0	2	1	50.0	0	0	00.0	1	1	100.0
	Total	352	334	94.9	50	46	92.0	55	52	94.5	47	44	93.6
Total	I	1264	1233	97.5	152	145	95.4	176	169	96.0	135	130	96.3
	II	259	193	74.5	42	29	69.0	50	37	74.0	26	19	73.1
	III	80	27	33.8	13	3	23.1	13	2	15.4	4	2	50.0
	Total	1603	1453	90.6	207	177	85.5	239	208	87.0	165	151	91.5

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment--these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 8. Recovery of birds stricken with botulism during 1953 and 1954 in relation to their relative body condition

Year	Sick Class	Hospital Treatment																	
		Inoculation									Fresh Water								
		Body Condition									Body Condition								
		Skinny			Medium			Fat			Skinny			Medium			Fat		
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%
1953	I	221	217	98.2	185	181	97.8	29	28	96.6	237	218	92.0	98	93	94.9	17	13	76.5
	II	67	57	85.1	28	23	82.1	4	4	100.0	71	39	54.9	18	9	50.0	2	2	100.0
	III	32	11	34.4	5	2	40.0	0	0	00.0	21	4	19.0	7	0	00.0	3	0	00.0
	Total	320	285	89.1	218	206	94.5	33	32	97.0	329	261	79.3	123	102	82.9	22	15	68.2
1954	I	57	55	96.5	28	28	100.0	6	6	100.0	46	43	93.5	26	26	100.0	7	7	100.0
	II	14	12	85.7	5	4	80.0	0	0	00.0	14	12	85.7	5	4	80.0	0	0	00.0
	III	6	4	66.7	0	0	00.0	0	0	00.0	1	0	00.0	1	0	00.0	0	0	00.0
	Total	77	71	92.2	33	32	97.0	6	6	100.0	61	55	90.2	32	30	93.8	7	7	100.0
Total	I	278	272	97.8	213	209	98.1	35	34	97.1	283	261	92.2	124	119	96.0	24	20	83.3
	II	81	69	85.2	33	27	81.8	4	4	100.0	85	51	60.0	23	13	56.5	2	2	100.0
	III	38	15	39.5	5	2	40.0	0	0	00.0	22	4	18.2	8	0	00.0	3	0	00.0
	Total	397	356	89.7	251	238	94.8	39	38	97.4	390	316	81.0	155	132	85.2	29	22	75.9

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment--these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 8. Continued -

Year	Sick class	Field Treatments																	
		Inoculation									No treatment								
		Body condition									Body condition								
		Skinny			Medium			Fat			Skinny			Medium			Fat		
		T[1]	R[2]	%[3]	T	R	%	T	R	%	T	R	%	T	R	%	T	R	%
1953	I	67	67	100.0	55	54	98.2	25	25	100.0	66	66	100.0	47	47	100.0	33	32	97.0
	II	20	17	85.0	6	3	50.0	3	3	100.0	17	12	70.6	4	3	75.0	2	0	00.0
	III	4	1	25.0	1	0	00.0	1	1	100.0	2	0	00.0	1	0	00.0	0	0	00.0
	Total	91	85	93.4	62	57	91.9	29	29	100.0	85	78	91.8	52	50	96.2	35	32	91.4
1954	I	41	41	100.0	56	56	100.0	19	19	100.0	45	45	100.0	52	52	100.0	14	14	100.0
	II	7	7	100.0	3	3	100.0	0	0	00.0	4	2	50.0	1	1	100.0	1	1	100.0
	III	0	0	00.0	2	0	00.0	0	0	00.0	1	0	00.0	2	1	50.0	0	0	00.0
	Total	48	48	100.0	61	59	96.7	19	19	100.0	50	47	94.0	55	54	98.2	15	15	100.0
Total	I	108	108	100.0	111	110	99.1	44	44	100.0	111	111	100.0	99	99	100.0	47	46	97.9
	II	27	24	88.9	9	6	66.7	3	3	100.0	21	14	66.7	5	4	80.0	3	1	33.3
	III	4	1	25.0	3	0	00.0	1	1	100.0	3	0	00.0	3	1	33.3	0	0	00.0
	Total	139	133	95.7	123	116	94.3	48	48	100.0	135	125	92.6	107	104	97.2	50	47	94.0

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment--these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.

Table 8. Continued -

Year	Sick class	Total								
		Body condition								
		Skinny			Medium			Fat		
		T[1]	R[2]	%[3]	T	R	%	T	R	%
1953	I	591	568	96.1	385	375	97.4	104	98	94.2
	II	175	125	71.4	56	38	67.9	11	9	81.8
	III	59	16	27.1	14	2	14.3	4	1	25.0
	Total	825	709	85.9	455	415	91.2	119	108	90.8
1954	I	189	184	97.4	162	162	100.0	46	46	100.0
	II	39	33	84.6	14	12	85.7	1	1	100.0
	III	8	4	50.0	5	1	20.0			
	Total	236	221	93.6	181	175	96.7	47	47	100.0
Total	I	780	752	96.4	547	537	98.2	150	144	96.0
	II	214	158	73.8	70	50	71.4	12	10	83.3
	III	67	20	29.9	19	3	15.8	4	1	25.0
	Total	1061	930	87.7	636	590	92.8	166	155	93.4

1. Designates the total number of birds treated.
2. Designates the total number of treated birds not found dead after treatment--these birds were assumed to have recovered.
3. Designates the percent of birds recovering after treatment.