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SPECIES SUSCEPTIBILITY TO AVIAN CHOLERA [1]

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Abstract

Data obtained on losses occurring among various species of waterfowl due to avian cholera were analyzed statistically. Coots, gulls, rodents and rabbits were inoculated with suspensions of *Pasteurella multocida.*

The relation between population size of the individual waterfowl species and the respective mortality rates was not statistically sigificant. No correlation could be found for the average weights and the death rates occurring in each species. The widgeon duck, white-fronted goose and coot had higher losses from avian cholera than other waterfowl. Gulls were more resistant to *P. multicoda* than the coot, and the laboratory rat was completely resistant whereas the Norway rat was susceptible.

Introduction

Annual epizootics of avian cholera have been recorded in the wintering waterfowl in California for the past 25 years. There have been considerable fluctuations in the mortality rates each year as well as in the incidence among the various species affected. A few aspects of the disease have remained fairly constant, particularly the seasonal occurrence and the geographic distribution. However, some of the factors influencing the appearance and course of the epornitics remain unknown.

Both a vertical and a horizontal epizootiological approach[3] in the study of avian cholera have been applied. The horizontal method was exemplified in observation at Tule Lake where avian cholera was introduced into the biota[7] as well as tularemia[5] while a *Microtus* irruption was occurring. The vertical technique incorporating the analysis of data is the primary subject matter of this paper.

Disease in epizootic proportions is generally considered to be density dependent, therefore the first question was whether a relationship existed between the size of the waterfowl population, the species composition of that population, and the losses from avian cholera. Another factor was if physical condition played a part in the comparative mortality of the diverse waterfowl species. Petrides and Bryant[6] indicated a correlation between body weight of the individual species and the deaths occurring in those species from pasteurellosis, and it was deemed advisable to test their contention. Finally, it is known that animal species differ in their susceptibility to certain diseases, and it has been shown that selective breeding may enhance resistance to disease as demonstrated in the case of pasteurellosis;[2] therefore, through the analysis of the data gathered during the past decade an indication of differential susceptibility might be obtained.

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Materials and Methods

Total losses incurred by all species of waterfowl from avian cholera were estimated each April since 1944 as the epizootics ended. The estimates were made on state and federal waterfowl areas by experienced observers and in other areas by personnel who have worked with disease losses for the past two decades. There is no question that the figures are inaccurate, but they do provide a continuing index of relative mortality each year. In order to provide a more reliable comparison of yearly losses, annual aerial surveys have been made each February since 1957 and whistling swan *(Olor columbianus)* carcasses have been counted. The flights covered the Sacramento and San Joaquin River delta islands and the Sutter and Yolo Bypasses of the Sacramento River, which enzootic region is approximately 1,500 square miles.

During outbreaks of avian cholera sample areas were surveyed on the ground and the individual species collected were recorded. All birds diagnosed in the laboratory with death due to pasteurellosis were recorded by species. Relative mortality rates for the species were derived from these two sources.

The preliminary diagnosis of avian cholera was based on pathology and the occurrence of bipolar rods in blood smears viewed through the microscope. Confirmed diagnosis was by isolation of *Pasteurella multocida* and biochemical characterization.

Winter inventories of waterfowl species throughout California and in specific areas in the state were made when avian cholera was affecting the birds. The surveys of the ducks, geese, swans and coots *(Fulica americana)* were performed by aerial photography.[2]

Experimental trials on comparative susceptibilities of experimental animals, coots and gulls were by intraperitoneal inoculation with *P. multocida*. The initial dose was a 0.5 ml saline suspension of bacteria equated to McFarland number one, and then adjusted to higher or lower concentrations until an LD_{100} was determined or complete resistance demonstrated.

Waterfowl were trapped throughout California, separated according to species, weighed and the depth of pectoral muscle measured to find an index of physical condition. This procedure was begun prior to winter continued at 4 week intervals until avian cholera occurred.

All of the collected data was analyzed statistically and tested for significance. Relative mortality of each species was compared with the numbers of dead mallards *(Anas platyrhynchos)* as an arbitrary base.

Results

Whistling swan winter populations for each year from 1957 through 1969 and the aerial counts of swan carcasses for the same periods were recorded (Figure 1). Analysis of the figures gave a correlation coefficient of .09 which indicated that during the thirteen years there was no relation between size of the population and losses incurred. Comparison between data for 1961 and 1962 indicates that despite a drop of 28% in the population the mortality increased 520%.

Data was obtained at Tule Lake in 1958 relative to duck mortalities (Table 1). Widgeon ducks *(Mareca americana)* accrued losses 99 times as great as the mallard and 31 times more than the green-winged teal *(Anas carolinensis)*. Calculating mortality factors and average weight of the species as done by Petrides and Bryant[6] gave a correlation coefficient of .04 or no relation.

The results obtained during different outbreaks of avian cholera varied consideraly in the relative mortalities for the different species (Table 2). Although values differed, the widgeon had a high mortality among those ducks affected.

As a result of different death rates observed in time and location, the averages of the species counted in the winter inventories for the decade 1961 through 1969 were compared with losses in each

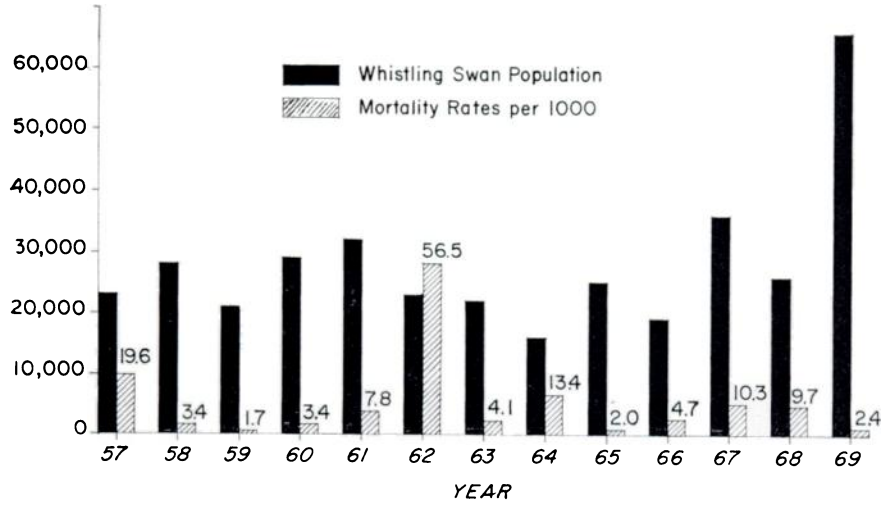

FIGURE 1.

species during the same period (Table 3). The correlation coefficient was —.08 which again indicated no relationship between the average weight and mortality of the individual species. Furthermore the combined figures indicate that the widgeon was six and a half times as susceptible as the mallard, and the white-fronted goose *(Anser albifrons)* was ten times more affected by avian cholera than the snow *(Chen hyperborea)* or cackler geese *(Branta canadensis minima)*. The pintail *(Anas acuta)* had only half the losses of the mallard. The coot

TABLE 1. *Comparative mortality of waterfowl species due to avian cholera at Tule Lake Refuge, 1968*

		Waterfowl Percentage Composition		Numbers of Deaths		Mortality Ratings [2]	Relative Mortality [3]
Species	Census	Alive	Dead	Found	Expected [1]		
Mallard	53,960	59.6	3.4	42	737.9	5.7	1.00
Pintail	9,175	10.1	12.1	150	125.0	120.0	21.05
Widgeon	13,035	14.5	81.8	1013	179.5	564.3	99.00
Greenwinged teal	8,035	8.9	1.6	20	110.2	18.1	3.18
Coot	6,300	6.9	1.1	13	85.4	15.2	2.67
Total	90,505	100.0	100.0	1238	1238.0		

[1] From percentage species composition of live waterfowl.

[2] Percentage of expected deaths which were realized.

[3] Compared to the mallard.

TABLE 2. *Relative mortality of waterfowl species due to avian cholera during different epornitics compared to the mallard*

Species	Colusa 1957 [1]	Tule Lake 1958 [2]	Yolo Bypass 1966 [3]	Merced 1968 [4]
Whitefronted goose				75.90
Snow goose				13.06
Mallard	1.00	1.00	1.00	1.00
Pintail	0.23	21.05	0.08	0.87
Widgeon	16.17	99.00	2.56	13.65
Shoveler			7.20	
Greenwinged teal	13.08	3.18	0.68	0.40
Ruddy				24.00
Coot	106.22	2.67	5.41	

Based on carcasses identified and estimated population of live waterfowl

[1] 1,561 carcasses and 87,050 live waterfowl

[2] 1,238 carcasses and 90,505 live waterfowl

[3] 298 carcasses and 44, 515 live waterfowl

[4] 355 carcasses and 125,665 live waterfowl

TABLE 3. *Comparative mortality of waterfowl due to avian cholera in California from 1961 through 1969*

Species	Average Annual Population	Waterfowl Percentage Composition		Numbers of Deaths		Mortality Ratings [2]	Relative Mortality [3]
		Alive	Dead	Found	Expected [1]		
Whitefronted goose	136,206	3.0	19.6	1228	188	653.1	24.64
Snow goose	480,350	10.6	6.8	427	664	64.3	2.42
Cackling goose	128,874	2.9	1.6	102	182	56.0	2.11
Mallard	361,450	8.0	2.1	133	501	26.5	1.00
Pintail	1,618,742	35.9	5.2	328	2250	14.5	0.54
Widgeon	669,003	14.8	25.7	1610	927	173.6	6.55
Shoveller	235,636	5.2	3.1	192	326	58.8	2.21
Ruddy	117,839	2.6	0.2	15	163	9.2	0.34
Greenwinged teal	258,374	5.7	1.2	76	357	21.2	0.80
Cinnamon teal	5,284	0.1	0.4	26	6	433.3	16.35
Coot	504,349	11.2	34.0	2129	702	303.2	11.44
Total	4,516,107	100.0	99.9	6266	6266		

[1] From percentage species composition of live waterfowl.

[2] Percentage of expected deaths which were realized.

[3] Compared to the mallard.

is one species which died from this disease at a high rate compared to other waterfowl. Relative mortality for cinnamon teal *(Anas cyanoptera)* is misleading since only 26 were identified in the 10 years, and the low average annual number alive enlarges the mortality out of proportion.

Intraperitoneal inoculation of *P. multocida* in 24 gulls and 24 coots gave an LD_{100} of 4.6×10^8 for gulls and 4.6×10^2 for coots. The gulls died in 48 to 72 hr whereas the coots succumbed within 12 hr. Gulls and coots exhibited this differential susceptibility despite the same average weight of 800 g with a range of 500 to 980 g for both species.

The guinea pig, rabbit, laboratory mice and Norway rat were susceptible to avian cholera, but the laboratory rat was resistant.

Attempts failed to demonstrate a loss of weight and decline in physical condition resulting from the stress of hunting season, climatic conditions and possible lowered nutrition within the individual species of the waterfowl population. Considerable variation in the physical measurements of individuals within each species was observed. One group of 500 male pintails, all trapped in one location at the same time, had a mean maximum thickness of the pectoral muscle of 18.4 mm with a range and standard deviation of 13 - 25 mm and 2.1 mm. Their mean weight was 885 g with a range and standard deviation of 600 - 1175 g and 86.3 g. Continued sampling of male pintails in the winter gave values within these outside ranges. A similar variation was found in the other ducks and particularly mallards.

Discussion

One of the precepts of pharmacology is that a drug should be administered on a dosage-weight relation. This is not a usual concept applied to infectious disease, although a subject in poor physical condition is usually considered more susceptible to infection. Petrides and Bryant[6] had good evidence of a species-weight relationship to avian cholera susceptibility, but they admitted that the data did not correlate when considered for any 2 week period. The data given here does not substantiate their findings.

Physical condition may have an influence on the severity of an epornitic of avian cholera and it may be responsible for a differential mortality between species. The techniques used to measure condition of the birds were not successful in substantiating or disputing the hypothesis.

No relation between the total numbers and losses incurred by a species is indicated by the data in this paper. A comparison of swan losses and annual populations exemplifies this disparity. Another source of evidence is the comparatively light death rate among pintail ducks which are the most numerous waterfowl species in the Pacific Flyway. However, population density is considered important in the transmission of disease *per se*, but another factor is not the total population of the waterfowl or of any one species, but rather how locally concentrated the birds are. The 1969 outbreak of pasteurellosis was extremely light despite average populations and severe winter storms. The rainfall was almost twice normal with considerable flooding, and the presence of more water tended to disperse the birds, which may have been responsible for the comparatively lower mortality.

There is a definite differential species susceptibility to avian cholera as shown by Heddleston and Watko[4] who exposed chickens and turkeys via nasal clefts with *P. multocida*. All of the turkeys died but only 25% of the chickens succumbed. Bhasin[1] found that palatine exposure with a single strain of the organism caused high losses in turkeys whereas chickens were unaffected. This study demonstrated the greater susceptibility of coots over gulls. Complete resistance to *P. multocida* was demonstrated by the laboratory rate whereas the Norway rat was susceptible.

Although the evidence indicates a greater susceptibility to avian cholera among widgeon and white-fronted geese than other ducks and geese other factors should be considered. The habits and

habitats of the individual species could be important in exposure to the disease. A comparison of the pintail and widgeon shows the pintail as a deeper feeder and it spends less time on dry land than the widgeon, whereas the widgeon grazes as geese and loafs on the mudflats. There may be an ecologic relation between the edge of the ponds where contaminated feces is available as well as a greater concentration of carcasses. In 1964 about 100 snow geese died on a small pond and the carcasses were removed. The water in that pond along the shoreline was infective for injected mice for 3 weeks after the dead geese had been withdrawn. Waterfowl which landed on that pond might have contracted avian cholera, but no more occupied the pond and no further losses occurred. However, the shallow, still water at the edge of the pond was a potential focal point where widgeon might have had more opportunity to contract the disease than pintails.

Further examination of records indicates that more than population size of the species or differential susceptibility derived from statistical evaluation influenced the relative mortality. In 1962 the swan death rate was 56.5 per thousand and the duck loss was about 1.4 per thousand. In 1966 the swan loss was 4.7 per thousand and ducks died at the rate of 25 per thousand. This discrepancy suggests that the species should be considered as distinct units in the study of epizootics especially in an ecological approach.

Differential susceptibility of those species most affected by avian cholera should be tested in the laboratory under controlled conditions. This information would give a clearer picture of one factor which influences epizootiological data obtained on a marsh during an avian cholera outbreak.

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