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AN EPIDEMIOLOGICAL SURVEY OF AVIAN TUBERCULOSIS IN LIVESTOCK, POULTRY, AND WILD BIRDS IN RICH COUNTY, UTAH

by

Royal Thair Carver

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Bacteriology

UTAH STATE UNIVERSITY
Logan, Utah

1969

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Appreciation is extended to all those who assisted in typing, editing, and correction of errors. Finally, to my wife, Norma, and our children, for patience and understanding, I extend a husband's and father's gratitude.

Royal Thair Carver

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

An Epidemiological Survey of Avian Tuberculosis

in Livestock, Poultry and Wild Birds

in Rich County, Utah

by

Royal Thair Carver, Master of Science

Utah State University, 1969

Major Professor: Dr. Paul B. Carter
Department: Bacteriology

A study was conducted in Rich County, Utah to determine the extent of avian tuberculosis in livestock, poultry and wild birds. Sensitivity was elicited in cattle, swine and chickens by tuberculin testing.

The Mycobacterium avium organism was obtained from tissues and specimens of cattle, swine, goats, chickens, magpies and sparrows.

Methods of eradication of avian tuberculosis and the relationship of avian tuberculosis to mammalian tuberculosis are discussed.

(49 pages)

INTRODUCTION

The United States Department of Agriculture, Agricultural Research Service, Animal Health Division are always interested in improving methods of control and eradication of diseases, which would provide livestock and poultry products that are not a hazard to human health. Bovine tuberculosis eradication has been a program since 1917 but avian tuberculosis has not been considered a problem.

For a disease to be considered for control or eradication, it must either be an economic burden, represent a public health hazard, or both. Avian tuberculosis in man does represent a public health problem. It is not only an economic burden but makes the present mammalian tuberculosis eradication more costly and difficult.

The initiation of this study in Rich County, Utah, was the result of increasing reports of avian tuberculosis infection in cattle, swine and poultry. It was recommended that a survey be conducted to determine the extent of infection in livestock and wild birds that might provide information to justify the need for an avian tuberculosis program in this and other similar areas.

The objectives of the study were to conduct a surveillance for avian tuberculosis infection in cattle and swine originating from Rich County. This surveillance was in cooperation with meat inspection in local slaughtering establishments. Tuberculin testing of cattle, swine and poultry was done to determine the extent of infection and reliability of the tuberculin test. Samples were obtained from the major types of wild birds found in the area, so as to determine if avian tuberculosis in wildlife is

associated with the farm animals.

REVIEW OF THE LITERATURE

Tuberculosis has plagued man and animals since the beginning of recorded time. Koch in 1882 (28) showed the tubercle bacillus to be the causative agent of tuberculosis. He felt that the same bacilli caused disease in man, animals and birds. Rivolta (51) in 1883 challenged Koch's belief in the unity of the tuberculosis organism regardless of the host. Rivolta's work received little acceptance because of the fame and work of Koch on tuberculosis. Maffucci (36) in 1892 presented unequivocal evidence that the organism causing tuberculosis in birds was a separate and distinct variety of the tubercle bacillus, differing in cultural and pathogenic properties from the organism responsible for tuberculosis in man, confirming the earlier conclusions of Rivolta. Even with this work, it was not until 1901 that Koch finally admitted that there was indeed a difference (29).

Crisp (9) in 1868 was among the first to describe tuberculosis in chickens, although not knowing its cause. He was able to transmit the disease from tuberculous chickens to healthy chickens. Larcher (33) described what was considered to be a case of tuberculosis in a duck. In 1872, Paulieki (46) summarized observations of spontaneous diseases of birds in the Hamburg Zoo and considered tuberculosis to be a tumor-like disease. Near the close of the nineteenth century, avian tuberculosis was reported by Ribbert in Germany (50), Sutton and Gibbes in England (64), Hebb in Scotland (24), and by Cameron in Ireland (4). Sibley (57) gave quite an accurate and comprehensive description of the morbid anatomy of avian tuberculosis. The avian organism was isolated from birds by Strauss

and Gamaleia (61) in 1891. Bray (3) in the United States reported a condition in chickens that probably was tuberculosis. No laboratory confirmation was made. Pernot (47) demonstrated the disease in six different flocks. Since 1900, world-wide infections in domestic and wild fowl have been reported. There is little doubt that avian tuberculosis is common among both domestic and wild birds, and that Mycobacterium avium for this reason is a suitable nomenclature.

From 1900 to 1940, numerous reports of avian tuberculosis have appeared in the literature. Interest in this disease in animals other than fowl was important in the 1930's but only a mild interest in human infections. During the past few years, reports of avian tuberculosis infections have appeared in the literature in increased numbers, including man. It is of interest to note that what is being said about the problem of avian tuberculosis today, especially in livestock and man, is the same as it was 30 years earlier (5, 6, 8, 12, 15, 48, 56).

In the past, public health agencies and veterinary medicine have said there is no problem with man and avian tuberculosis because man is not susceptible (26, 38, 59). Early reports in human cases of authentic avian tuberculosis are extremely rare. Feldman (12), in his book cites 13 cases from 1905 to 1936 in which avian tubercle bacilli were demonstrated and 24 cases from 1894 to 1935 in which data was insufficient to support a diagnosis, but could have been avian tuberculosis infection.

Recent literature confirms that cases of infection seem to be on the increase. Nassal (44) in 1961 cited 268 cases of human tuberculosis from which the causative organism was isolated and typed. Twenty-three or 8.5 per cent were typed as M. avium, of which 12 or over 50 per cent were pulmonary disease. Marks and Birn (38), because M. avium closely resembles anonymous or atypical mycobacteria, investigated anonymous strains collected

by the Tuberculosis Reference Laboratory of England during a 10-year period. The study was confined to 16 isoniazid-resistant thermophilic strains taken at random from a series of 18 pathogens. Ten strains proved to be M. avium by pathogenicity tests. All 10 strains were lethal for fowls, and six were lethal for rabbits.

Cheung and Konst (7) cited a case of pulmonary tuberculosis apparently caused by the avian tubercle bacillus. In spite of continuous chemotherapy this patient with chronic pulmonary disease contained organisms that conformed to known properties of M. avium.

Engbaek (11) in 1964, reported that three fatal cases of M. avium infection occurred within a course of about 1 year in a family of five members in Denmark. Kubin et al. (31, 32) cite nine cases of avian tuberculosis in Czechoslovakia. They point out the seriousness of the disease's clinical course and prognosis as a reason for the elimination of avian tuberculosis from natural sources, particularly in regions where the human population is no longer exposed to wide-spread infection by mammalian mycobacteria.

In Utah (49) in 1966, two cases involving school children were reported. The findings were the result of biopsies taken from involved lymph nodes in the head and neck regions, thought to be cancerous. One case was found during a school health examination. The tissues were submitted to E. H. Runyon, Chief Bacteriologist at the Veteran's Hospital in Salt Lake City, Utah. Runyon was able to isolate organisms from both cases which were later typed as M. avium at the Jewish Children's Hospital in Denver, Colorado. The Animal Health Division studied the epidemiology of these two cases. One case, a 10-year-old boy from Vernal, had a history of playing with wild birds, some that were sick. The other case was a 7-year-old male in Salt Lake County that resided in a home containing pet

song birds. The boy's grandparents had a flock of chickens with which the boy may have had contact. Tuberculin testing of the pet birds and chickens were negative. Attempts to isolate the avian organism from the song birds by Runyon were unsuccessful.

Human sensitivity to avian or avian-like strains interferes with the eradication program against infections with mammalian strains. Edwards (10) and Smith et al. (59) report that avian tubercle bacilli and other mycobacteria are sources of tuberculin sensitivity in the human population.

The confusion of the human infections involving the avian-like, battey type, and other Runyon group III mycobacteria create another problem. Many investigators feel that there is a distinct possibility that the organisms are all M. avium. Smith et al. (58) indicate that the mutability of avian bacilli greatly exceed that of human and bovine species. The difference seems to be only virulence. Meissner (39) and Scammon et al. (54) have shown that virulence can be changed by temperature and host adaptability. Perhaps these different strains, differing only in virulence, are related. Wayne (70) feels that group III, battey bacilli of human origin are difficult, if not impossible, to distinguish with assurance from cultures of M. avium that have lost virulence for birds and proposed that the group III organisms of the battey type be considered M. avium rather than a separate species. Runyon (52, 53) does not feel quite this strongly about grouping the different strains, but agrees that it is a reasonable possibility that battey bacilli originated sometime, some place, from M. avium or vice versa. Regardless of what the future finds as a solution to this dilemma, if there is or isn't an interrelationship of these strains, the problem needs further study.

Numerous reports of avian tuberculosis in cattle and swine, and to a lessor extent in other domestic animals, have been published. Swine are

very susceptible to avian tuberculosis as shown by Graham and Tunnicliff (16) with extensive experiments. The susceptible nature of swine to infection by both direct or indirect exposure was observed. Sparrows and pigeons captured in the vicinity of tuberculous chickens showed hepatic or spleenic lesions when necropsied. The disease seemed to appear spontaneously among wild rats on or adjacent to infected premises.

Bickford, Ellis, and Moses (2) reported that a swine herd in Indiana was extensively infected. No poultry was present on this farm. The nearest chickens were about one-half mile away, and avian tuberculosis had been found in this flock earlier. Large numbers of starlings were near the infected hog lot, consequently, and after being captured, were found to be infected. Many of the lesions found in avian infected cattle are usually from cattle fed in lots that are frequented by wild birds.

Gwatkin and Mitchell (20) showed the ease and rapidity which swine may be infected with avian tuberculosis. Pigs were infected with avian tuberculosis by allowing them to eat chickens previously inoculated with M. avium. The pigs were tuberculin tested in 2 weeks, just prior to slaughter, and were positive to avian tuberculin, but not to mammalian tuberculin. After the pigs were destroyed, the organism was isolated from the tissues.

One of the first to suggest that cattle were susceptible to infection by the bacilli of avian tuberculosis was Kruse (30) in 1893. Van Es and Martin (68) reported an extensive study involving 164 cattle showing small isolated lesions principally in lymph nodes. One hundred fifteen specimens were infected with tuberculosis; 100 isolates were mammalian tubercle bacilli, 11 were avian, while four were a mixture of avian and mammalian. Many workers have cited cases of infection in cattle (18, 22, 25, 65, 67). Stuart and Marshall (62) isolated the avian organism from the bovine udder.

Minett (40) in Great Britain reports on avian tuberculosis in cattle where infected poultry were allowed to run freely with them.

Fincher, Evans, and Saunders (13) reported avian tuberculosis in the uterus of a recumbent 3-year-old guernsey cow. The source of this infection was believed to have been the result of chicken manure application to the pasture used by the guernsey herd. The 34 cows occupying this pasture were subsequently tuberculin tested using both avian and mammalian tuberculin. There were no responses to mammalian tuberculin, but 17 head were positive to avian tuberculin.

Nassal (43) reported that from lung, intestinal and cervical lymph node tissues of 357 cattle suspected of avian tuberculosis were tested, and in 53.8 per cent of the cases, M. avium was isolated and precisely differentiated.

Apparently tuberculosis in sheep is rare but most of the typed cases are of the avian type. However, Stubbs (63) found an unusual case of tuberculosis in sheep, and because of its rareness, performed differentiation tests. This case of tuberculosis was of the bovine type but the organism was also pathogenic for a chicken. The infected chicken reacted to avian tuberculin on the first test, but on retest with avian and mammalian tuberculin reacted only to the mammalian. The disease could not be transferred to other chickens, but did infect guinea pigs and rabbits. Harshfield and Roderick (23) reported finding four cases of avian tuberculosis in sheep at slaughter. They exposed 18 sheep to M. avium by oral ingestion and three sheep by intravenous injection. Only six sheep were infected, all by the oral route.

Goats also have been found to be infected with avian tuberculosis, but a paucity of literature exists. Beller (1) indicates that tuberculosis in goats in a danger to man, because of their use for milk and close

association with human beings. Griffith (17, 19) found avian tubercle bacilli in the milk of goats after subcutaneous injection of the organism and reports on an udder infection in a goat.

Domestic fowl are a known reservoir of avian tuberculosis, and wild birds seem a possible reservoir and vector for this organism. Mitchell and Duthie (41) reported avian tuberculosis in the common crow. Lukes (34) reported finding M. avium in three wild birds, a black-headed gull, a jack-daw, and a sparrow hawk. Wilson and MacDonald (71) reported finding generalized avian tuberculosis in six adult golden eagles. They reviewed findings of avian tuberculosis in house sparrows, starlings, pigeons, gulls, ducks, waders, hawks, owls, and many captive birds.

Further studies and investigations should be made on the possibility that avian tuberculosis is being passed to man in eggs from infected poultry. Investigators in this area seem to indicate that infection to man from this source is of little importance. Van Es and Schalk (69), Fitch et al. (14), and Stafseth et al. (60) reported isolations of M. avium from eggs, from the reproductive tract, and from the outside of the shell of infected chickens.

Chicken offal is commonly used uncooked as mink feed. Hall and Winkel (21) in 1957 give a case report of avian tuberculosis in mink. Since it is not commonly reported, mink must not be highly susceptible to the organism.

Not all of the possible sources of infection with the avian organism have been covered. Feldman (12) cites a few sources that should be mentioned. M. avium can survive in soil and be viable and virulent for long periods of time. Organisms buried at a depth of 3 feet for 27 months, and barnyard soil and litter have been known to contain virulent bacilli after 4 years. The earthworm may be a possibility of increasing survival

time. Larvae of flies on decomposed carcasses of infected birds could be a vector in the spread of disease. Equipment, feeds, and supplies that are transported one farm to another could be a means of spread of avian tuberculosis.

MATERIALS AND METHODS

Tuberculin

Standard United States Department of Agriculture avian and mammalian tuberculins, and the standard tuberculin test procedures of USDA (37) for cattle, swine and poultry were used.

Tissues

As far as practical, necropsies were performed on cattle, swine, poultry, and on all of the wild birds. Tissues were collected from slaughtering establishments and isolations attempted, using the facilities of the Veterinary Science Diagnostic Laboratory at Utah State University. When tissues were sufficient in quantity, these were also submitted to the National Animal Disease Laboratory (NADL) at Ames, Iowa, for isolation. All isolates of acid-fast organisms were submitted to NADL for confirmation and typing. The procedures of isolation from tissues at the Veterinary Science Laboratory were those recommended by NADL, which are as follows:

1. The tissues were observed grossly for lesions, cut into small pieces and fat trimmed away.
2. Tissues were placed in a blender with enough nutrient broth to cover the specimens. The tissue and broth were mixed for about 2 minutes or until there was a fluid consistency.
3. The mixture was placed into a sterile beaker containing 100-150 ml of 5 per cent papain and 60 mg/l of cysteine hydrochloride solution with enough 4 per cent NaOH added to make the mixture just alkaline. The mixture then was digested on a magnetic mix-o-stirrer at 45 C for 1 1/2 hours.

4. The digested tissues were filtered through sterile gauze and 10 ml placed into a sterile screw-capped tube containing 10 ml of 4 per cent NaOH (with phenol red indicator) and centrifuged at 2000 rpm for 15 minutes.
5. The supernatant was poured off and discarded. An acid-fast and gram stain smear was made from the sediment to observe for micro-organisms. The rest of the sediment was neutralized with 0.2 N HCl solution.
6. The neutralized solution was inoculated by pipette on Lowenstein-Jensen and Stonebrink nutrient agar slants in screw-capped tubes, incubated for 24 hours on their side, and then upright at 37 C and observed daily for growth. The media was freshly prepared as required and in accordance with procedures recommended by NADL, Ames, Iowa.

Cattle and swine surveillance at slaughter

Lymph nodes with lesions suggestive of tuberculosis were collected by inspection personnel, placed in a 1 per cent chloromine T solution and submitted to NADL at Ames, Iowa, or to the Utah State University Veterinary Science Diagnostic Laboratory for isolation work.

Trapping methods for wild birds

Variations of the Australian crow trap and the New York starling trap (45, 66) were used to capture magpies. Starlings were shot using a 16 gauge shotgun with large pellet type shells. Sparrows were shot with an air rifle pellet gun or captured in buildings such as chicken coops by hand.

Description of Rich County

The location of Rich County in the State of Utah is shown in Figure 1. The county is bordered on the north by Idaho and on the east by Wyoming. Four Utah counties are to the west and south, but geographically separated by rugged mountain ranges.

The county has an area of approximately 1,031 square miles, with a population of about 1,673 people. A mountain range divides the county into a northern and a southern half, the latter contains the county seat, Randolph, Utah (see Figure 2).

The main industry in the county is beef cattle ranching, and includes about 33,000 cattle and calves. The second most important industry is sheep grazing, approximately 43,000 head at times are in the county but only about 20 per cent are sheep owned in the county. Swine, poultry and other types of farming are of little economic importance. At the start of this study there were 4,306 poultry in the county and approximately 400 swine. Only about 400 of the cattle are of the dairy type which are family cows.

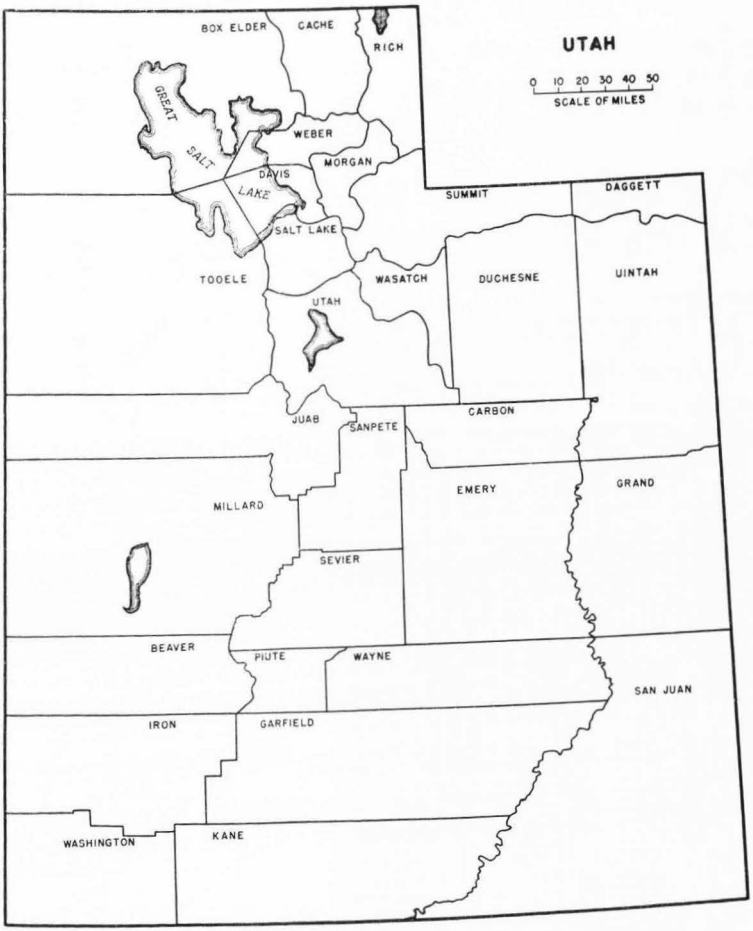

Figure 1. Counties in the State of Utah

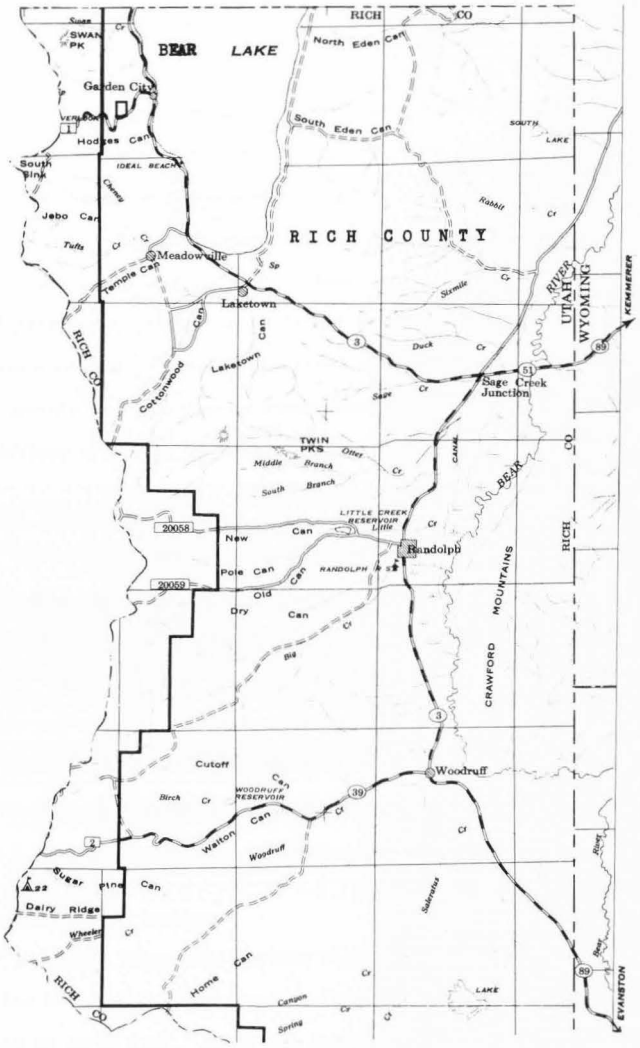

Figure 2. Rich County--Towns and Roads

RESULTS

Cattle and swine surveillance at slaughter

Surveillance of livestock originating from Rich County revealed eight cattle and one pig with lesions suggestive of avian tuberculosis. These tissues were submitted from two federally inspected plants in Rich County and Cache County, Utah. Seven of the eight cattle were positive on histopathology, disclosing acid-fast bacilli within tissue changes typical of tuberculosis. Three of the seven animals, M. avium was cultured. The one pig was positive on histopathology and culture for M. avium. Isolations are shown in Table 1.

Cattle tuberculin testing

During the period May, 1965 to May, 1967, tuberculin tests using both avian and mammalian tuberculin were conducted on 402 cattle on five premises. Many tests were retests on the same cattle (see Table 2). Of the 402 tests, 19 were sensitive to avian tuberculin. Only three, two calves and a bull,were necropsied and tissues screened for infection. The three animals were from the same farm, No. 7, Figure 3. Isolations were made from tissues of these three animals. The two calves were infected with M. avium and the bull was infected with M. paratuberculosis.

Swine tuberculin testing

The swine tuberculin testing was conducted on one herd during 1966 and the swine tested three times. The rest of the breeding swine were tested in April 1967. Isolation attempts were made on three pigs. M. avium was isolated from one of the pigs. The test data are summarized in Table 3.

Table 1. Summary of M. avium isolations in cattle and swine under slaughter surveillance

Date	Location of herd of origin[a]	Species	Tissues submitted	Laboratory findings	
				Histopathology	Culture
2-18-65	Garden City (1)	Bovine	mesenteric lymph nodes	+	+
4-21-65	Garden City (1)	Porcine	mandibular lymph nodes	+	+
5-11-65	Meadowville (2)	Bovine	mesenteric lymph nodes	+	+
11-18-66	Randolph (3)	Bovine	mesenteric lymph nodes	+	-
10-4-67	Woodruff (4)	Bovine	cervical lymph nodes	+	-
11-20-67	Woodruff (5)	Bovine	mesenteric lymph nodes	+	+
2-27-68	Laketown (6)	Bovine	mesenteric lymph nodes	+	-
2-28-68	Laketown (6)	Bovine	mesenteric lymph nodes	-	-
5-20-68	Woodruff (5)	Bovine	mesenteric lymph nodes	+	-

[a]Number shows location of premise on county map, Figure 3.

Table 2. Summary of M. avium isolations in cattle as a result of tuberculin testing

Test date (OBS)	Number tested	Reactors Avian	Reactors mammalian	Reactors Total	Location of herd tested[a]	Laboratory findings Histopathology	Laboratory findings Culture	Number animals cultured
5-3-65	107	5	1	5	Laketown (7)	+	+	1 calf
7-9-65	1	1	1	1	Laketown (7)	+	+	1 calf
10-29-65	9	0	0	0	Randolph (8)			none
3-21-66	12	0	0	0	Randolph (8)			none
5-16-66	94	4	2	4	Laketown (7)			none
5-19-66	1	0	0	0	Meadowville (9)			none
9-30-66	1	1	1	1	Laketown (7)	+	M. paratuberculosis	-- bull
12-15-66	8	0	0	0	Randolph (10)			none
1-19-67	1	0	0	0	Randolph (3)			none
5-26-67	168	8	2	8	Laketown (7)			none
Totals	402	19	7	19				

[a]Number shows location of premises on county map, Figure 3.

Table 3. Summary of M. avium isolations in swine as a result of tuberculin testing

Test date (OBS)	Number tested	Reactors Avian	mammalian	Total	Location of herd tested[a]	Laboratory findings Histopathology	Culture	Number animals cultured
2-21-66	41	2	2	2	Laketown (7)	-	-	1 pig
5-19-66	39	18	7	18	Laketown (7)	-	-	1 pig
11-11-66	33	10	3	10	Laketown (7)			none
4-17-67	21	2	1	2	south half of County (11 premises)	+	+	1 pig
4-18-67	14	0	0	0	north half of County (5 premises)			

[a]Number shows location of premises on county map, Figure 3.

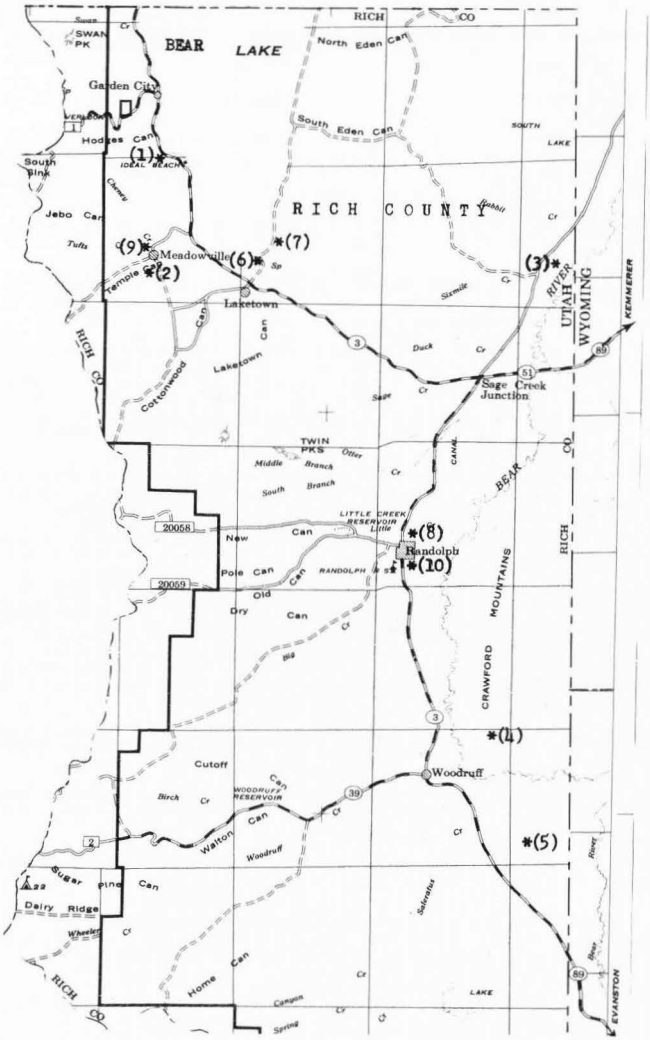

Figure 3. Rich County--*M. avium* isolates of cattle, swine and goats

Poultry tuberculin testing survey

In October, 1964 two chickens were diagnosed as being infected with avian tuberculosis at the Veterinary Science Diagnostic Laboratory, Utah State University. These chickens were from a commerical flock containing approximately 2,000 leghorn hens. The infected chickens were from a coop containing about 1,000 older hens. This older group were tested a week later and over 50 per cent of the chickens were sensitive to avian tuberculin. The flock was sent to slaughter and over one-third of the birds showed gross lesions of tuberculosis. On July 19, 1965 the younger flock on this farm was tested and 12 reactors to avian tuberculin found. The 12 hens showed gross lesions of tuberculosis. This flock was sent to slaughter and some gross lesions of tuberculosis were found in chickens negative to the tuberculin test. The location of the premise is Farm 7, county map, Figure 3.

Survey of all the poultry was started using the tuberculin test throughout the county. Many of the flocks had originated from the above commercial flock (Farm 7) as cull hens. Chickens of 99 flocks were tested in the survey. The flocks contained 4,306 poultry, of which 4,275 were chickens. The other 31 fowl were ducks, geese and turkeys. Where large numbers of reactors were found on testing and the owner consented, the flock was completely destroyed and the premises cleaned and disinfected. Forty-two premises during the survey were cleaned and disinfected under federal inspection. Of the 99 flocks, 57 flocks had reactors which contained 3,457 chickens or about 80 per cent of the total in the county. There were 349 reactors found, 56 chickens were necropsied from a few of the farms and all but two chickens showed gross lesions of tuberculosis. Nine non-reactors were necropsied and three contained gross lesions of avian tuberculosis. Forty-one chickens had lesions involving the liver,

spleen, and intestines. Of the 41, generalized tuberculosis involving bone was found in three chickens, and one chicken had lung involvement. The other 16 chickens necropsied had gross lesions in only one organ. The banty type flocks were quite free of tuberculosis and may not be as susceptible to the organism as other chicken breeds. Banty flocks were not confined in chicken coops as were the other types of poultry. The poultry tuberculin testing results are summarized in Tables 4, 5, 6, and 7. Location of poultry tested in shown on county map, Figure 4.

Table 4. Poultry tested with avian tuberculin

1.	Total flocks tested		99
2.	Total poultry tested		4,306
	a. Laying type chickens	3,928	
	b. Broiler type chickens	81	
	c. Banty type chickens	266	
	d. Ducks, geese and turkeys	31	

Table 5. Results of poultry tuberculin tests

1.	Reactor flocks		57
2.	Negative flocks		42
3.	Number of chickens in reactor flocks		3,457
4.	Number of chickens in negative flocks		858
5.	Avian tuberculin positive chickens		349
	a. Laying type chickens	342	
	b. Broiler type chickens	0	
	c. Banty type chickens	7	
	d. Ducks, geese and turkeys	0	
6.	Flocks, banty only		19
7.	Negative banty flocks		15
8.	Per cent of reactor flocks		56.6
9.	Per cent of reactor chickens		8.1
10.	Per cent of banty reactors		2.6

NOTE: Results do not include reactors found in October, 1964 when flock was over 50 per cent avian tuberculin positive.

Table 6. Poultry necropsy

1.	Flocks completely destoryed	28
2.	Reactors destroyed	349
3.	Reactors necropsied	56
4.	Non-reactors necropsied	9
5.	Total poultry necropsied	65
6.	Reactors showing gross lesions	54
7.	Non-reactors showning gross lesions	3

Table 7. Tissues and organs involved in lesion chickens

	Liver only	Spleen only	Liver, spleen and intestines	Lung, liver, spleen and intestines
Minute lesions	5	8	16	0
Extensive lesions	0	3	24	1
Totals	5	11	40	1

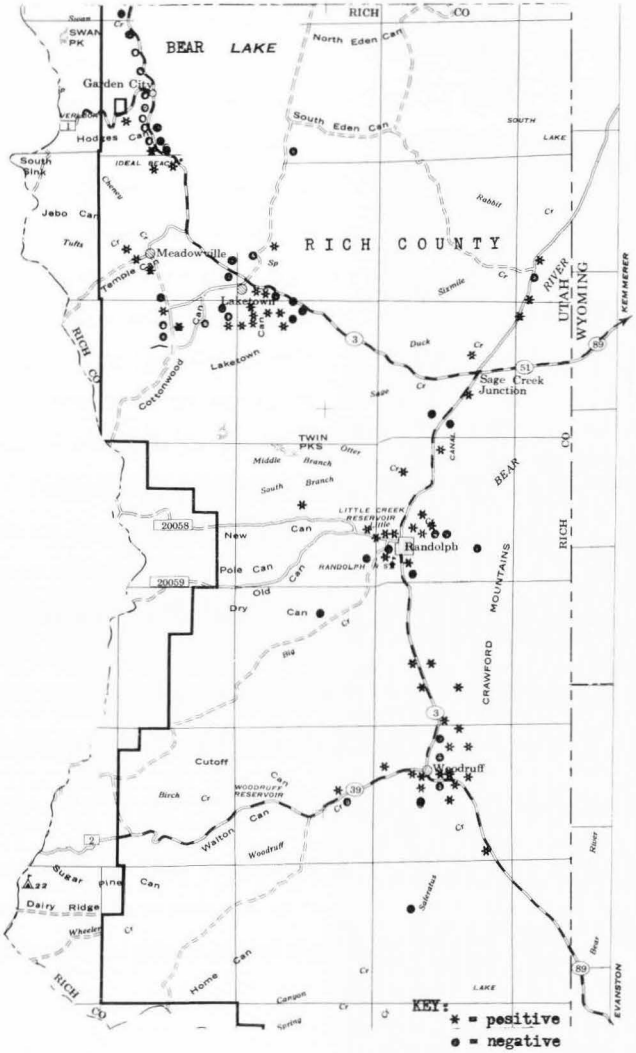

Figure 4. Rich County -- Tuberculin positive and negative poultry flocks

Goats

During a poultry tuberculin test a flock of 43 chickens was tested with avian tuberculin and 17 were found to be reactors. The farm was located in Randolph, Utah (Farm 8, Figure 3). The owner requested a tuberculin test be done on his cattle and two goats because the family was drinking the raw milk from both. The cattle were negative to avian and mammalian tuberculin but one goat was positive to both tuberculins. The reactor goat was not lactating and it was considered a suspect. On the retest, the previous reactor was again positive to both tuberculins and the goat being used for the milk supply was sensitive to avian tuberculin. At the request of the owner, the goats were taken to the University for tests to determine the source of sensitivity.

Tracheal mucous, urine, feces, vaginal swabs and milk were obtained from the goats for culturing for acid-fast organisms. Specimens were collected and cultures done for a 4-month period. M. avium was isolated from the urine of one goat, and acid-fast organisms from the feces of the other goat. Tuberculin tests were conducted during the study to determine sensitivity to several tuberculins.

At the end of the study, the goats were killed and isolations attempted from tissues. The goat from which the M. avium urine isolate was obtained was negative on tissues on histopathology and culture. From the other goat acid-fast bacilli were observed. The tissues showed changes typical of tuberculosis but no isolation was obtained from cultures. Results of the goat study are summarized in Tables 8, 9, and 10.

Table 8. Culturing of goat specimens and tissues for mycobacteria

	Tracheal mucous	Urine	Feces	Milk	Vaginal swabs	Tissues	
						Histopathology	Culture
Adult goat	-	+(a)	-	-	-	-	-
Kid goat	-	-	+(b)			+	-

(a) Urine acid-fast isolate--*M. avium*, serotype II.

(b) Feces acid-fast isolate--soil saphrophyte - Runyon IV.

Table 9. Goat caudal fold test--avian and mammalian tuberculins

Goat	Date	Avian response (mm)	Mammalian response (mm)
Adult	10-29-65	-	-
Kid	10-29-65	1½ mm X 3 mm	slight
Adult	3-21-66	1 mm X 1 mm	-
Kid	3-21-66	4 mm X 12 mm	1½ mm X 1½ mm
Adult	6-3-66	½ mm X ½ mm	-
Kid	6-3-66	1 mm X 1 mm	slight

Table 10. Goat cervical (neck) test--using 9 different tuberculins

Tuberculin	Skin thickness increase in mm. Adult goat	Kid goat
Mammalian	1.3 mm	1.5 mm
Avian	1.4 mm	1.4 mm
Standardized avian[a]	1.0 mm	0.7 mm
PA[b]	2.4 mm	3.0 mm
PB[b]	3.6 mm	0.9 mm
Old tuberculin--(mammalian O. T.)	3.1 mm	1.2 mm
Mycobacterium balnei	1.3 mm	2.9 mm
Non-photochromogen (Runyon Gp III)	1.6 mm	1.7 mm
M-129--milk isolate (Chapman-Texas)[c]		

[a]Regular avian tuberculin standardized to USDA mammalian tuberculin.

[b]PA and PB tuberculins were prepared from organisms from cattle lesions obtained in Cache County, Utah, Runyon Group II and IV types.

[c]Tuberculin made from a milk isolate by Chapman in Texas.

Wild bird survey

The wild birds found most often near cattle and swine feeding areas and poultry buildings were magpies, sparrows and starlings. During the Winter of 1964-65, M. avium isolates were obtained from a magpie and a sparrow captured near areas containing infected chickens. In 1967, during January and February, 192 wild birds were trapped or shot for this study. There were 84 magpies, 66 sparrows, and 42 starlings. Isolation of M. avium was attempted. The birds were grouped by species and according to location obtained. From 25 groups, M. avium organisms were isolated from four groups. The isolates were obtained from both magpies and sparrows. No isolation was made from starlings. Results are given in Tables 11, and 12.

Table 11. Sparrows

Sparrows per group	Tubes showing growth[a]	Growth first observed	Location obtained[b]	Isolation	Serotype
9	0/8	none	B	none	
10	0/8	none	B	none	
9	0/8	none	B & C	none	
9	0/8	none	B	none	
9	1/4	6 days	A, E & D	none	
10	5/8	16 days	B	M. avium	not typed
10	1/7	3 days	B	none	
66	7/48			1	

[a]Tubes showing growth over tubes inoculated.

[b]See Figure 5.

Table 12. Magpies

Magpies per group	Tubes showing growth[a]	Growth first observed	Location obtained[b]	Isolation	Serotype
7	7/8	17 days	A	*M. avium*	I
7	1/8	3 days	E	none	
8	1/8	6 days	D	none	
7	0/8	none	A	none	
5	0/4	none	A	none	
6	0/4	none	E	none	
7	0/4	none	D	none	
8	4/4	16 days	B	*M. avium*	I
7	0/7	none	A	none	
8	0/7	none	D	none	
7	0/7	none	D	none	
4	1/7	3 days	B & E	none	
3	3/8	26 days	A	*M. avium*	not typed
84	18/84			3	

[a]Tubes showing growth over tubes inoculated.

[b]See Figure 5.

Serotypes

Serotyping of M. avium by NADL was by the method of Schaefer and Reggiardo (55). The typing was done on some of the cultures submitted (Table 13). Two different serotypes were found in the magpies.

Table 13. Serotypes of some of the Rich County M. avium isolates

Host & year isolated	Tissue source	Serotype	NADL TB case number
Sparrow (1965)	Liver and spleen	II	1976
Calf (1965)	Mesenteric lymph n.	II	208
Magpie (1965)	Liver and spleen	II	209
Goat (1966)	Urine specimen	II	210 a & b
Magpies (1967)	Liver and spleen	I	1792
Magpies (1967)	Liver and spleen	I	1793
Sparrows (1967)	Liver and spleen	Too dry to type	1794

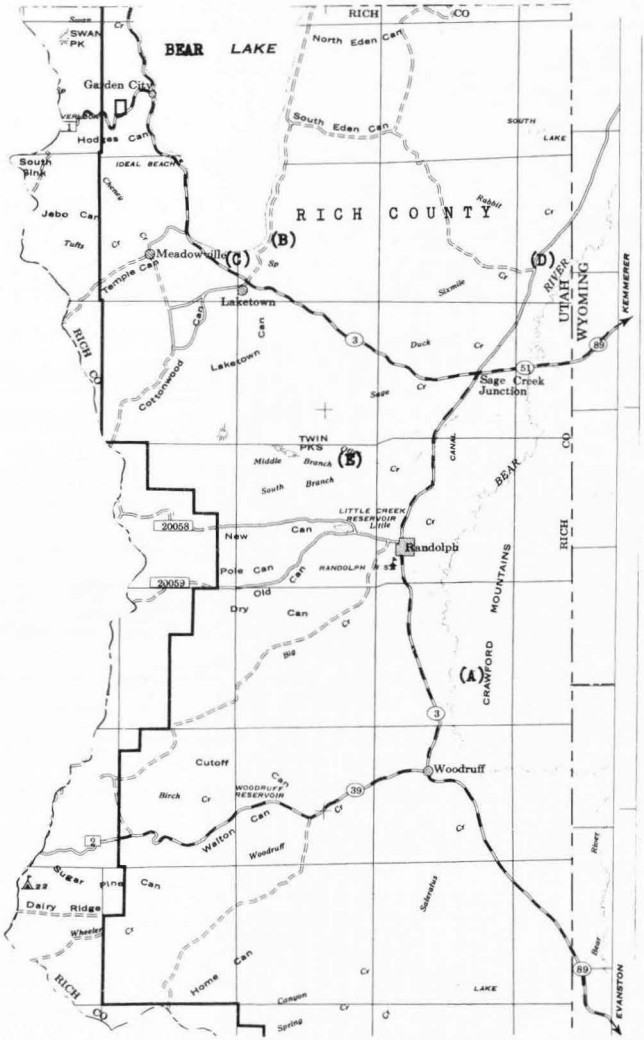

Figure 5. Rich County--areas where the wild birds were captured

DISCUSSION

The economic burden of avian tuberculosis in the livestock industry is becoming more and more important. The disease in man is being considered a possible public health hazard. Infections in man and animals are interfering with the eradication program against mammalian strains. Yet there is still an apathy towards any action against avian tuberculosis. A need for an eradication program for this disease is indicated by its world-wide prevalence. Perhaps further work will be required to justify the initiation of such a program. Investigations of hosts, host adaptability, reservoirs and vectors should be done. More information is needed on the possibility man may be infected from meat products, eggs and milk. The disease is a possible occupational hazard because the organism is present in livestock and poultry.

The economic loss in the swine industry is substantial. In 1965, 1.2 million swine carcasses were retained because of tuberculosis with a loss of $1,900,870. Condemnations because of tuberculosis in poultry amounted to over $178,000 for the same period. Poultry loss on the farm due to avian tuberculosis is estimated to have cost $499,000 with an approximate egg loss of $1,500,000 annually.

In the cattle industry, avian tubercle bacilli isolated from bovine lesion cases at NADL represent 16 per cent of the total isolates and approximately 50 per cent of the mesenteric lymph node specimens examined. The establishment of an avian tuberculosis eradication program would assist the bovine tuberculosis program achieve its goals. Many cattle react to an injection of mammalian tuberculin because of sensitization induced by

avian tuberculosis. This creates a special problem in testing that tends to distort the true incidence of bovine tuberculosis and has led to indifference in proper interpretation of the mammalian tuberculin test. Laboratory facilities for examination of suspected tissues of bovine and swine are severely taxed in manpower and time because of the necessity of differentiating avian and bovine tuberculosis.

Avian tuberculosis in cattle is probably more widespread than is being reported. During fiscal year 1968, there were 198 lesion cases submitted to NADL for culture, as a result of meat inspection. These cases were received from only 18 of the 50 States, and 96 cases were from Wisconsin. During this period, 14 cases were from Utah that were generated primarily by this study. The disease, usually with non-progressive type lesions, is not easily found and often overlooked at meat inspection.

The usual solution of eradication of tuberculosis in cattle and swine is tuberculin testing, removal of reactor animals and retesting until sensitivity discontinues. With avian tuberculosis this method will work with poultry but will not solve the problem with cattle and swine. If tuberculin testing of cattle and swine were conducted in Rich County, sensitivity and infection would be found. We would eradicate the livestock but not the disease. The disease must first be eliminated from the reservoirs and vectors. Suggestions for the solution of the problem are as follows:

1. Education of the public to the hazards of maintaining old poultry flocks and allowing poultry to contact other farm animals.

2. Tuberculin testing of old flocks and a surveillance system on commerical operations such as in poultry processing plants. The development of an effective blood test for screening blood samples that are routinely submitted to diagnostic laboratories from poultry on other

diseases. Karlson et al. (27) and Moses et al. (42) have done some preliminary work with whole blood agglutination tests but further work is required.

3. The surveillance of cattle and swine at slaughter could be a means of tracing infection back to infected poultry or other sources.

4. Enlist the help of the Wildlife Service in problem areas to diminish the numbers of wild and useless birds to a reasonable level, thus controlling them as a source of spread of disease.

5. The facilities of public health and animal health should be used to the fullest extent to determine the source of the disease in human avian infections.

6. When the disease is controlled or eradicated from the reservoirs and vectors, then tuberculin tests on cattle and swine could economically be used for final eradication of the disease.

Isolations of M. avium were found in Rich County in cattle, swine, poultry, goats and wild birds. Poultry still carry the disease but compared to the original infection, it is at a low level. The disease is still present in cattle, wild birds, and probably swine. Since three of the cattle isolates of the organism were not associated with chickens, their source of infection appeared likely from wild birds. The infection occurred on farms where the poultry was confined or running free and was also found in wild birds on these farms. The disease was found on well-managed premises as often as poorly-managed ones.

The swine tested in this study points out the tuberculin cross-reaction resulting from sensitivity to mycobacteria. The herd that was tested three times showed nearly half of the pigs sensitive on one test and the sensitivity fluctuated between tests and between pigs. Infection in this swine herd has never been found. This again demonstrates the problem of the

tuberculin testing program with mammalian tuberculin.

The technical difficulty of obtaining isolations of acid-fast growth from tissues was also evident in this study. Identical tissues processed at two laboratories did not always yield the same results. Organisms were successfully isolated in one laboratory but were not found by the other laboratory.

M. avium isolated from magpies were both serotypes I and II while those isolated from other birds and animals were of serotype II. Serotype I is considered rarest of the two types.

Avian tuberculosis should and can be controlled. Available knowledge on this disease supports the need for an effective eradication program. The control of avian tuberculosis would contribute greatly to the eradication of mammalian tuberculosis in man and animals.

SUMMARY

During the past few years in Rich County, Utah avian tuberculosis has been found in increasing frequency in poultry, cattle and swine. A surveillance was started on livestock at slaughtering plants and tuberculin testing conducted on poultry and livestock. Wild birds were captured and cultured by Mycobacterium avium. During the surveillance, M. avium was isolated from five bovine and two pigs and four other cows which yielded negative on cultural growth showed acid-fast bacilli within tissue and tissue changes compatible with avian tuberculosis.

A test of all poultry in the county was conducted with avian tuberculin. Ninety-nine flocks were tested and 57 flocks contained reactors. Over 50 per cent of one flock reacted to tuberculin and represented nearly half of the poultry population in the county. The other flocks tested averaged 8.1 per cent reactors. The poultry served as a source of infection in cattle and swine.

A survey on wild birds from various areas within the county resulted in six isolations of M. avium from magpies and sparrows.

Two goats were reactors to avian tuberculin. M. avium was isolated from the urine of one goat and the other goat showed acid-fast bacilli within tissue. No isolation of the organism was made from this goat.

Methods of eradication of avian tuberculosis and the relationship of avian tuberculosis to mammalian tuberculosis are discussed.

LITERATURE CITED

1. Beller, K. Tuberculosis in goats a danger to human beings. Hippokrates, Stuttgart, p. 670, 1952. (Original not seen; abstracted in Vet. Bull., 16:339).

2. Bickford, A. A., Ellis, G. H., and Moses, H. E. Epizootiology of tuberculosis in starlings. Amer. Vet. Med. Assn. Jour. 149:312-318.

3. Bray, T. A. Tuberculosis in chickens. Vet. Jour. 43:13-14. 1896. (Original not seen; cited in Feldman (12).)

4. Cameron, C. A. Tuberculosis in fowls. Tr. Roy. Acad. Med. Ireland. 7:368-371. 1889. (Original not seen; cited in Feldman (12).)

5. Chaloux, P. A. Editorial. Tuberculosis Review, United States Department of Agriculture, Agricultural Research Service, Animal Health Division. No. 3, September 1964.

6. Chaloux, P. A. Editorial. Tuberculosis Review, United States Department of Agriculture, Agricultural Research Service, Animal Health Division. No. 5, November 1964.

7. Cheung, O. T. and Konst, H. Pulmonary tuberculosis apparently caused by the Avian Tubercle Bacillus. Canad. Med. Assn. J. 89:116. 1963.

8. Crawford, A. B. Studies in Avian Tuberculosis. Amer. Rev. Resp. Dis. 37:631-635. 1928.

9. Crisp, Edwards. Tubercle in the common fowl, from a damp atmosphere. Tr. Path. Sec. London. 20:441-442. 1868-1869. (Original not seen; cited in Feldman (12).)

10. Edwards, Lydia, Edwards, Phyllis Q. and Palmer, C. E. Sources of tuberculin sensitivity in human populations. Acta. Tubercul. Scand. Supp. 47:77. 1959. (Original not seen; abstracted in Tuberculosis Review, USDA, ARS, ANH. No. 4. October 1964.)

11. Engaek, H. C. Three cases in the same family of fatal infection with M. avium. Acta. Tubercul. Scand. 45:105-117. 1964. (Original not seen; abstracted in Amer. Rev. Resp. Dis. 93:484. March 1966.)

12. Feldman, W. H. Avian Tuberculosis Infections. Baltimore: Williams and Wilkins Company, 1938. pp. 1-31, 444-469.

13. Fincher, M. G., Evans, W. M. and Saunders, L. Z. Avian tuberculosis in a dairy cow. Cornell Vet. 44:240-252. 1954.

14. Fitch, C. P., and Lubbehusen, R. E. Completed experiments to determine whether Avian Tuberculosis can be transmitted through the eggs of tuberculous fowls. Amer. Vet. Med. Assn. Jour. 72:636-649. 1928.

15. Francis, John. Tuberculosis in Animals and Man. Baltimore: Williams and Wilkins Company, 1958. pp. 249-263.

16. Graham, Robert and Tunnicliff, E. A. Fowl tuberculosis in swine. Trans. Ill. Acad. Sci. 19:138-143. 1926. (Original not seen; cited in Feldman (12).)

17. Griffith, A. S. Excretion of Avian Tubercle Bacilli in the milk of goats after subcutaneous inoculation. Jour. Comp. Path. and Therap. 40:290-293. 1927.

18. Griffith, A. S. Tuberculosis of the domesticated species of animals. Jour. Comp. Path. and Therap. 41:109-112. 1928.

19. Griffith, A. S. Chronic infection of the udder of a goat with Avian Tubercle bacilli. Jour. Comp. Path. and Therap. 44:144-148. 1931.

20. Gwatkin, R. and Mitchell, C. Avian tuberculosis in swine. Canad. Jour. Comp. Med. 16:345-347. 1952.

21. Hall, R. E. and Winkel, F. Avian tuberculosis in a mink. A case report. Amer. Vet. Med. Assn. Jour. 131:49-51. 1957.

22. Harbour, B. A. Avian tuberculosis in cattle. Vet. Rec. 53:79-81. 1941.

23. Harshfield, G. S. and Roderick, L. M. Avian tuberculosis in sheep. Amer. Vet. Med. Assn. Jour. 85:597-610. 1934.

24. Hebb, R. G. Tuberculosis of fowls. Tr. Path. Soc. London. 39:471-472. 1887-1888. (Original not seen; cited in Feldman (12).)

25. Hruska, J. V., Mathey, W. J., Hall, C. F. and Van Ryzin, R. J. Avian tuberculosis in veterinary practice. Michigan State University Veterinarian. 19:24-31. 1958.

26. Karlson, A. G. Avian tuberculosis. Minnesota Med. 42:1399. 1959. (Original not seen; abstracted in Tuberculosis Review, USDA, ARS, ANH. No. 4. October 1964.)

27. Karlson, A. G., Zinober, M. R. and Feldman, W. H. A whole blood, rapid agglutination test for Avian tuberculosis. A preliminary report. Amer. Jour. Vet. Res. 11:137-141. 1950.

28. Koch, Robert. Die Aetiologie der Tuberkulose. Berl. Klin. Wchnschr. 19:221-230. 1882. (Original not seen; cited in Feldman (12).)

29. Koch, Robert. Address before second general meeting of the British Congress on tuberculosis. Tr. British Com. on Tuberc. London. 1:23-35. 1902. (Original not seen; cited in Feldman (12).)

30. Kruse, Walther. Ueber das Vorkemmen der sog. Huhnertuberkulose beim Menschen und bei Saugethieren. Ziegler's Beitr. 12:544-551. 1893. (Orignial not seen; cited in Feldman (12).)

31. Kubin, M., Dvorsky, K., Eisenerova, R., Mezensky, L., Franc, K. and Matejka, M. Pulmonary and non-pulmonary disease in humans due to Avian mycobacteria. Amer. Rev. Resp. Dis. 94:31-39. 1966.

32. Kubin, M., Kruml, J., Horak, Z., Lukavsky, J. and Vanek, C. Pulmonary and non-pulmonary diseas in humans due to Aviran mycobacteria. Amer. Rev. Resp. Dis. 94:20-30. 1966.

33. Larcher, O. Note pour servir a l'histoire de la tuberculisation de foie chez les oiseaux. Rec. Med. Vet. 48:697-704. 1871. (Original not seen; cited in Feldman (12).)

34. Lukes, D. Tuberculosis in wild birds. Vet. Rec. 66:448-449. 1954.

35. Maffucci, Angele. Beitrag zur Aetiologie der Tuberkulose (Huhnertuberculose) Centralbl. f. allg. Path. u. path. Anat. 1:409-416. 1890. (Original not seen; cited in Feldman (12).)

36. Maffucci, Angele. Die Huhnertuberculose; experimentelle Untersuchungen. Ztschr. f. Hyg. u. Infectionshrankh. 11:445-486. 1891-1892. (Original not seen; cited in Feldman (12).)

37. Manual of Instructions Tuberculosis Eradication, USDA, ARS, Animal Health Division. Revised March 1964.

38. Marks, J. and Birn, K. J. Infection due to Mycobacterium avium. British Med. Jour. No. 5371, p. 1503. 1963. (Original not seen; abstracted in Tuberculosis Review, USDA, ARS, ANH. No. 5. November 1964.)

39. Meissner, Gertrud. The atypical mycobacteria - Bacteriological, clinical and epidemiological problems. Ergebnisse der Inneren Medizin Und Kinderheilkunde. 20:40-48. 1963. (Original not seen; abstracted in Tuberculosis Review, USDA, ARS, ANH. No. 4. October 1964.)

40. Minett, F. C. Avian tuberculosis in cattle in Great Britain. Jour. Comp. Path. and Therap. 45:317-330. 1932.

41. Mitchell, C. A. and Duthie, R. C. Tuberculosis of the common crow. Canad. Jour. Comp. Med. 14:109-117. 1950.

42. Moses, H. E., Feldman, W. H. and Mann, F. L. Mycobacterial rapid agglutination antigens and their diagnostic value in tuberculosis of fowl. Amer. Jour. Vet. Res. 4:390-394. 1943.

43. Nassal, J. Results and problems of Avian tuberculosis in cattle. Berliner und Munchener Tierarztliche Wochenschrift, 11:210. 1961. (Original not seen; abstracted in Tuberculosis Review, USDA, ARS, AHN. No. 5. November 1964.)

44. Nassal, J. The etiological and epidemiological roll of bovine and avian tubercle bacilli in the tuberculosis of man. Deutsch. Med. Wchscht. 89:1855-1861. 1961. (Original not seen; abstracted in Tuberculosis Review, USDA, ARS, ANH. No. 5. November 1964.)

45. New York Starling Trap. United States Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife Branch of Predator and Rodent Control. Boston. January 2, 1962.

46. Paulicki, August. Beitrage zur vergleichenden pathologischen Anatomie. In: Beitrage zur Pathologie der Vogel. Berlin, A. Hirschwald, Chapt. 3, pp. 67-88. 1872. (Original not seen; cited in Feldman (12).)

47. Pernot, E. F. Investigations of disease of poultry. Oregon Agricultural Experiment Sta. Bull. No. 64. Corvallis. 1900. (Original not seen; cited in Feldman (12).)

48. Ranney, A. F. An address on tuberculosis eradication at the 71st annual meeting of the USLSA. Phoenix, Arizona. October 19, 1967.

49. Rasmussen, J. E. Letter to Donald Miller, Assistant Director, Animal Health Division, USDA, August 18, 1966. (Dr. Rasmussen is the Veterinarian in Charge, Utah, Animal Health Div. USDA.)

50. Ribbert: Uber die Verbreitungsweise der Tuberkelbacillen bei den Huhnern. Deutsch. med. Wchnschr. 9:413-415. 1883. (Original not seen; cited in Feldman (12).)

51. Rivolta: Quoted by Maffucci, Angele (35). (Original not seen; cited in Feldman quoting Maffucci (12).)

52. Runyon, E. H. Pathogenic Mycobacteria. Adv. Tuberc. Res. 14:235-287. 1965.

53. Runyon, E. H. Mycobacterium intracellulare. Amer. Rev. Resp. Dis. 95:861-865. 1967.

54. Scammon, Lois, Froman, Seymour, and Will, Drake W. Enchancement of virulence for chickens of battey-type of mycobacteria by preincubation at 42 C. Amer. Rev. Resp. Dis. 90:804-805. 1964.

55. Schaefer, W. B. and Reggiardo, Z. Serological identification and classification of the mycobacteria other than M. tuberculosis encountered in human disease. Amer. Rev. Resp. Dis. 88:111. 1963.

56. Schalk, A. F., Roderick, L. M., Foust, H. L. and Harshfield, G. S. Avian tuberculosis: Collected studies. Tech. Bull. N. Dak. Agr. Expt. Sta. No. 279, pp. 46. 1935.

57. Sibley, W. K. Tuberculosis in birds. Jour. Comp. Med. and Vet. Arch. 11:317-334. 1890. (Original not seen; cited in Feldman (12).)

58. Smith, D. T., Conant, N. F. and Overman, J. R. 1964. Zinsser Microbiology, 13th ed. Meredith Publishing Company, New York. pp. 539-541.

59. Smith, D. T., Johnston, W. W., Cain, I. M. and Schumacher, M. Changes in the tuberculin pattern in students between 1930 and 1960. Amer. Rev. Resp. Dis. 83:213-234. 1961.

60. Stafseth, H. J., Bigger, R. J., Thompson, W. W., and Neu, L. The cultivation and egg transmission of the avian tubercle bacillus. Amer. Vet. Med. Assn. Jour. 85:342-359. 1934.

61. Straus, I. and Gamaleia, N. Recherches experimentales sur la tuberculose; la tuberculose; la tuberculose humaine, sa distinction de la tuberculose des oiseaux. Arch. de med. exper, et d'anat. path. 3:457-484. 1891. (Original not seen; cited in Feldman (12).)

62. Stuart, P. and Marshall, P. M. Avian tuberculosis of the bovine udder. Vet. Rec. 64:309. 1952.

63. Stubbs, E. L. Tuberculosis in sheep. Jour. of Bact. 39:339. 1940.

64. Sutton, J. B. and Gibbes, Heneage. Tuberculosis in birds. Tr. Path. Sec. London. 35:477-481. 1884. (Original not seen; cited in Feldman (12).)

65. Timoney, J. F. Avian tuberculosis in a cow. Vet. Rec. 51:191-243. 1939.

66. Trapping Starlings. United States Department of the Interior, Bureau of Sport Fisheries and Wildlife. Fish and Wildlife publication 210-65.

67. Van Es, L. Remarks on Avian tuberculosis infections in mammals. Amer. Vet. Med. Assn. Jour. 78:371-378. 1931.

68. Van Es, L. and Martin, H. M. The incidence of Avian tuberculosis in mammals other than swine. Agr. Expt. Sta. Res. Bull. 49. University of Nebraska, Lincoln. 1930.

69. Van Es, L. and Schalk, A. E. Avian tuberculosis. N. Dak. Agr. Expt. Sta. Bull. No. 108. pp. 3-94. 1914.

70. Wayne, L. G. Classification and Identification of mycobacteria. Amer. Rev. Resp. Dis. 93:919-928. 1966.

71. Wilson, J. E. and MacDonald, J. W. Tuberculosis in wild birds. Vet. Rec. 77:177. 1965.

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