AN EVALUATION OF ABATTOIR DATA

FOR DISEASE SURVEILLANCE.

This thesis represents 70% of the assessment requirements for the degree of Master of Philosophy at Massey University.

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ABSTRACT

Data from abattoirs were evaluated to determine their usefulness for disease surveillance. Self-acquired data from three surveys conducted at abattoirs and routinely generated disease statistics from meat export slaughterhouses were analysed.

Three techniques were employed in the analysis of these available data from New Zealand abattoirs. Returns from a large scale survey of bovine ocular squamous cell carcinoma were indexed on printed cards as a filing system and those from the serological surveys of two separate groups of abattoir workers were converted into computer system files. The "pencil and paper"-calculator method was used for the recorded disease statistics.

Conversion of survey returns into system files facilitated the handling of data. Manual sorting in a card index system provided new information on the epidemiology and economic importance of squamous cell carcinoma of the bovine eye in New Zealand. The rate of "cancer eye" in Herefords and Hereford crosses was 403/100,000 compared to 8/100,000 in other breeds. Further investigations indicated that these differences were associated with pigmentation of the ocular structures.

The data from the serological surveys among abattoir workers were conveniently manipulated in the computer and provided information of the risk factors involved in three potential zoonoses at the works. Both leptospirosis and brucellosis were shown to be occupational hazards. In the case of leptospirosis, direct pig contact appeared to constitute the greatest risk, while in brucellosis, one of the more important

correlations was in relation to time employed in the Meat Industry. Toxoplasmosis did not appear to be an occupational disease.

The information derived on these files were dependent on the manner of organisation (e.g. establishing variables from measurements, coding values) of the data originally obtained from the disease surveys carried out by others.

Routinely generated vital statistics of the prevalence of "Diseases and Defects" recorded by the Meat Division of the Ministry of Agriculture and Fisheries were examined and analysed. Analysis of variance tests were applied to selected conditions to determine regional variations. The application of statistical tests uncovered the subtleties of each group of data and revealed information on disease prevalences. True geographical variations in the prevalence of sarcocysts, caseous lymphadenitis and pleurisy of sheep were demonstrated.

Through these techniques useful information was derived from data generated by these three disease surveys carried out at the abattoir and from routinely recorded meat inspection statistics. Information obtained from the surveys is discussed in relation to previous studies on the same topics. Routinely recorded vital statistics were appraised for accuracy and their usefulness in studying variations in disease prevalence. The evaluation of data and information obtained during these investigations manifests the potential of the abattoir as a source of useful information for disease surveillance.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXAMPLES OF PROGRAMS,PRINTOUTS AND COMPUTATIONS

GENERAL INTRODUCTION

While there exist a wide range of technical bulletins, medical journals and index systems that describe scientific techniques and laboratory investigations, these sources seldom provide adequate surveillance information for disease prevention and control. Despite the current large volume of scientific publications, it is difficult to obtain precise, accurate and up-to-date information of the prevalence and economic importance of many diseases of livestock in specific countries or regions.

International reports, such as O.I.E. bulletins, tend to be inexact as to rates, location and timing of disease problems. In an evaluation of disease surveillance activities of international agencies, Ellis (1979) pointed out that absolute numbers of outbreaks without reference to the total population size can be misleading and that reports should indicate the proportion of animals or herds among those examined (prevalence) or the rate at which new infections are occurring in the number of animals (incidence) or production units still at risk.

There is an increasing recognition of the paramount importance of surveillance data from livestock industries, both in developed and developing countries. Davies (1979) makes reference to two major groups of data customers: firstly, those organisations and individuals that are responsible for the control of animal disease, and secondly, those that finance and operate research and development facilities. Another important and distinct group consists of the 'agri-business' managers and entrepreneurs, who increasingly require such surveillance information.

Davies (1979) attributes this increasing requirement of surveillance information to three reasons, namely :-

(1) the increasing recognition of the importance of movement of animals in the spread of disease,

(2) in sophisticated agricultural industries that are technologically based, industry must be able to identify and measure the difference between the cost of disease and the cost of prevention not only on a national scale but also at the producer level, and,

(3) the development of extensive research and development facilities that in the current economic and political climate must justify their existence.

The task of instituting surveillance is largely the remit of government. This is so because the activity should be closely linked with control and prevention measures which require a widely established and efficient organisation. Surveillance should either stimulate appropriate actions for the control and prevention of disease or be used to evaluate actions already instituted (Brachman, 1979).

For a national veterinary service and its allied organisations, surveillance may provide information to suggest whether a vaccination, or a slaughter policy, is a more effective control measure. In some cases it may show the inadequacy of past or present control measures. Good case reporting may also make it possible to recognise endemic diseases which previously might have been only considered sporadic cases as was the case of small intestinal carcinoma of sheep in New Zealand (Simpson, 1972). If this distinction is not recognised, an epidemic could ensue. Legionnaire's disease was not recognised until a returned soldiers convention at Philadelphia in 1976 attended by 3,683 delegates among whom 183 were affected with 29 deaths (Anon,1978a).

Its occurrence stimulated the recognition of two previously unrecognised episodes in England, one happened in 1973 and the other four years later, among Scottish tourists returning to Glasgow who became ill with alimentary and respiratory tract complaints after spending holidays in the same hotel in Spain (Boyd et al, 1978).

Information from surveillance activities may also be useful to health departments in their utilisation of personnel, equipment and money which should lead not only to increased efficiency but also to better control of the diseases under surveillance (Brachman, 1979).

The practitioner can benefit directly from surveillance by having the opportunity to see for himself the relationships of his case to the occurrence of that disease in the community and should enable him to be a more effective provider of health care. He may also gain important information concerning the most effective therapy.

As data customers, businessmen about to venture into a livestock industry need information to assess the potential profitability of their new enterprise. Feasibility studies structured on the drawing board must contain and use valid assumptions and facts that can withstand careful cost-benefit analysis.

The potential sources of surveillance data are diverse and immense. A list of direct sources listed by Davies (1979), Brachman (1979) and Schwabe et al (1977) include practitioners, abattoirs, packing plants, knacker yards, farms, laboratories, clinics, milk and dairy boards, meat and livestock commissions, zoo and wildlife study groups, serum banks, case and epidemic investigations and reports, disease control and eradication reports, quarantine reports, vector control reports, agricultural surveys, population surveys, biologic statistics, demographic data and the news media.

Developed countries with well organised and long established animal health control agencies may have some relatively extensive surveillance programmes which might include disease scheduling, planned disease surveys, sentinel farms and disease modelling.

Most of the above-mentioned sources may generate a multitude of data that has to be converted into useful information. Information is data that has been collected and modified in such a way that they are useful to somebody.

Data from abattoirs can establish trends in disease prevalence. Blair (1964) pointed out that as a result of thorough examination and recording of findings of literally billions of animals, veterinarians engaged in meat hygiene have made significant contribution to the understanding, control and even eradication of many serious animal diseases. He cited Meat Inspection Branch (M.I.B.) slaughtering records to establish that condemnation rates of beef carcases for squamous cell carcinoma in the U.S.A. was reduced from 14% in 1955 to 7% in the 1960's.

The use of the abattoir as source of surveillance data presents distinct advantages. Few extra-costs are incurred as studies can easily be conducted in existing premises and often from data already collected. Qualified and trained personnel are already available. The high killing capacity of many abattoirs permits a large number of observations to be made in a short period. Although examination of animals and carcases are relatively cursory there are many diseases that can be relatively accurately diagnosed by normal inspection procedures.

The abattoir is one of the least exploited sources of large scale surveillance data. Ladds (1979) observed that precise identification of animals coming to slaughter with information concerning their property or farm of origin, and the improvements in meat inspection procedures allow abbatoir observations to be

used as valuable tools in epidemiological and other studies. He concluded that 'successful implementation of research using abattoir methods demands excellent cooperation between the researcher, the abattoir veterinarian and the meat inspectors, the abattoir management, livestock buyers and the meat workers themselves. It is advisable that projects be discussed well in advance with all concerned and that some effort be made (e.g. seminars, slide evenings) to provide feedback information and conclusion. In all cases it is essential that observations and specimen collections be made with no (or at worst, minimal) disruption to the normal abattoir routine.'

Meat inspection in New Zealand is well-organised and has been established for many years. Abattoirs are under close supervision by the Meat Division (M.D.) of the Ministry of Agriculture and Fisheries (M.A.F.) and the Meat Act 1964 (Anon, 1964) and the Meat Regulations 1969 (Anon,1969) ensure proper execution of meat inspection procedures and maintenance of high standards of hygiene.

This contribution aims to investigate the possibility of exploiting to a greater extent the potential of abattoir data as a source of useful information. With this in mind, two major qualifications of abattoir data were critically appraised.

1. M.A.F. vital statistics already published routinely in terms of :
   (a) Accuracy
   (b) Usefulness for showing disease prevalence.
2. Disease investigations from data not normally recorded but easily generated, i.e. squamous cell carcinoma of the bovine eye (cancer eye),serological survey of meat inspectors and meat workers.

The work reported in this thesis is not primarily concerned with diseases themselves but with turning data to information. Therefore the emphasis will be on techniques for data handling, ranging from manual sorting to computer analysis and appropriate biostatistical techniques.

It is hoped that the knowledge and skills gained by the author from this work will provide a better insight and perspective of the current disease control and eradication programmes of the Bureau of Animal Industry (B.A.I.) of the Philippines.. A better understanding of surveillance and recording of data together with a greater expertise in manipulation and analyses of data and information should improve evaluation of the effectiveness and planning of certain current disease control programmes such as Foot and Mouth Disease. It is also hoped a stimulus will be provided to use abattoir data as a source of surveillance data in the country in the future.

CHAPTER 1

ANALYSIS OF MEAT WORKS "CANCER EYE" SURVEY IN NEW ZEALAND

INTRODUCTION

A survey of bovine ocular squamous cell carcinoma, commonly referred to as Cancer Eye, was carried out in eighteen selected meat export works (ME)*. The survey was organised by Professor D.K.Blackmore, Department of Veterinary Pathology and Public Health and carried out through the cooperation of the Society of Veterinary Public Health and the M.A.F. It was designed to produce some unique and fundamental information on the prevalence, economic importance and epidemiology of squamous cell carcinoma of the bovine eye in New Zealand and also to provide a clearer understanding of possible causally associated factors such as breed, location, age and season.

Ocular squamous cell carcinoma is a common spontaneous tumour of cattle. Ultra-violet radiation, genetic factors, nutrition and infection are among the many factors implicated in the etiology of the disease (Russell et al 1956). It was also cited that the disease has been reported widely in North America and to a lesser extent in other continents.

Majority of previous investigations were carried out in the U.S.A. Recognising the great research interest and potential of this neoplastic disease, the Cancer Eye Study Section was organised in 1952 at the University of Texas M.D. Anderson Hospital and Tumour Institute for the activation and prosecution of research in bovine ocular squamous cell carcinoma (Clark, 1956). Russell

* Abattoirs in New Zealand are generally referred to as being either local abattoirs or meat export works.

et al (1956) have studied the subject quite extensively, and their contribution provides an excellent historical review and a detailed histopathological description of the tumour.

Russell et al (1956) cite several surveys using abattoir data. In a review of slaughtering records of the M.I.B. of the U.S.D.A., Brandly and Migaki (1963) found a prevalence of 190/100,000 in 1955, and 323.3/100,000 in 1962. Blair (1964), who also analysed slaughtering records found 0.18% (180/100,000) prevalence in 1950 and 0.36% (360/100,000) in 1963. In Rumania, Ivascu and Onet (1974) examined 363,000 cattle in 1974 and found that 0.13% of them had ocular tumours. In India, Naik and Randelia (1975) found 185 cases in 79,492 slaughtered cattle at Madras abattoir or a 0.23% prevalence in 1975.

Abattoir surveys of bovine ocular squamous cell carcinoma are more reliable compared with other diseases because this tumour is more readily diagnosed clinically and easier to confirm by biopsy than tumours of other organs.

The present study was based on the use of a card index system in the handling of data acquired from Professor Blackmore's "cancer eye" survey. Findings were further supplemented by two smaller studies on pigmentation of the eye of cattle by the author. One was conducted at Longburn and Feilding meat works and the other at the Gisborne meat works. An evaluation of the original design of the survey was also undertaken.

MATERIALS AND METHODS

A card index system was employed to organise the data for analysis using AZ64 printed cards. This card is similar to a 5"x8" index card except that it is provided with punch holes, 3mm in diameter, along the edges, each hole being immediately adjacent and identified to a corresponding letter or number.

Duly completed forms composed the compilation of individual case reports of "cancer eye" (see Appendix 1 : a sample return of "cancer eye" survey). Examination and recording of cases were administered by the supervising veterinarian of the works concerned. Data from these entries were restructured onto the index card.

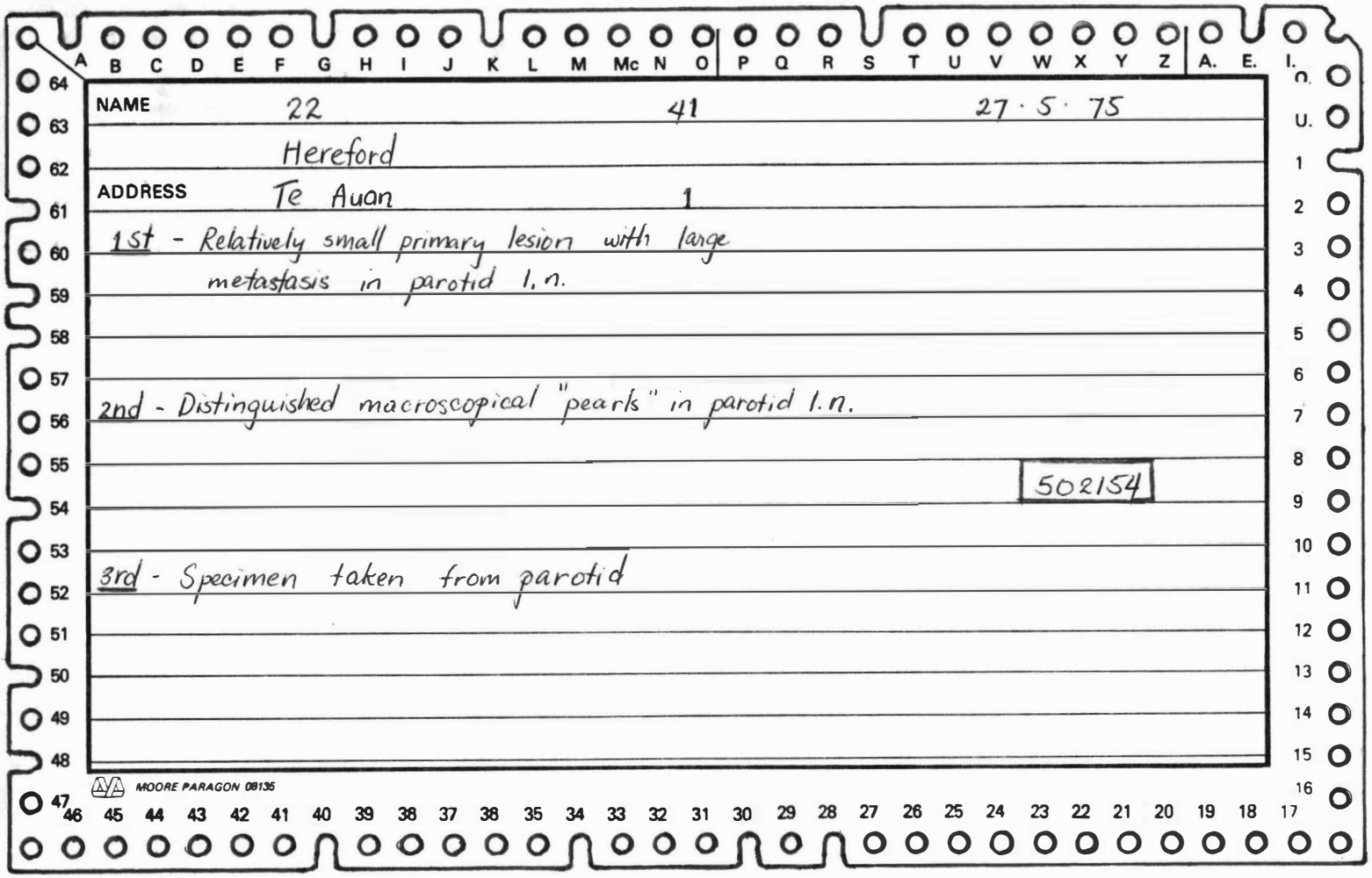
Each category of responses to a variable was assigned a code letter or number on the index card. The codes used to represent response for a variable were assigned in such a way that they appeared one after another, or as close as possible. In most variables a code was also assigned to indicate no response.

Eighteen variables were needed to record the answers to the questions in the case record forms. Breed responses were coded as A for Hereford, B for Hereford cross, C - Friesian and Friesian cross, D - other breeds and E was used where breed of affected animals was not indicated. The list of variables and the symbols in the AZ64 card used as codes and their description are shown in Appendix II : Card Index System Code.

Actual entry of data was achieved by clipping through the external edge of the hole that corresponded to a predetermined code. All data from a case were entered into one printed card. Figure 1 illustrates an AZ64 card with a completed entry of data found from the sample return cited above.

Additional data were written on the face of the card. On the first line were indicated the ME no., submitter's case reference no., and the date examined. The breed of the affected animal was written on the second line, followed on the third line by origin, number of animals in the line, and case reference nos. of other cattle in the line affected. Comments recorded by the examining veterinarian were listed. The first comment described the gross

FIGURE 1 : AN AZ64 PRINTED CARD WITH DATA ENTERED.



appearance of the lesion, the second provided additional findings on site(s) and extent of metastases if present and the third contained other comments.The laboratory reference no., if applicable, was indicated at the lower half of the right hand section of the card.

Cases were grouped together according to submitting meat works. The values of the data recorded on the cards were sorted into various categories by passing a thin pointed metal "needle" through the appropriate hole in a bunch of cards that was carefully "squared off". After insertion of the needle the cards were lifted and gently shaken allowing those which have been clipped for the attribute under consideration to drop off. Categories were laid out separately and tally counts were made. The contributing ME's served as sub-groups, each ME having been represented in the tally sheet. A working total was reached from these subtotals.

Additional data were provided by the survey summary report that was submitted by the ME veterinarian upon termination of the survey. The summary furnished data on the monthly cattle kill, an estimate of the Hereford and Hereford cross in the monthly kill, the inclusive dates on the duration of the survey, and the total number of cases encountered.

Various rates such as those relating to prevalence, age, and sex were obtained by manipulation of data from cards. Breed and geographical distribution of cases were explored. The economic importance of the disease to the meat industry was assessed from carcase condemnation rates according to beef export prices during the time of the survey.

Two projects were undertaken to supplement available data on pigmentation. The first one was conducted mid 1979 at Feilding and Longburn works for a comparative examination of pigmentation between Herefords and Hereford crosses.

Criterion for scoring was the presence of pigment on the eyelid, third eyelid and sclera. Accuracy of findings was evaluated by microscopic examination of wax embedded histological sections of the ocular structures using Masson Fontana method for melanin (Pearse, 1972).

A larger study of ocular pigmentation was carried out on November 26th to December 13th, 1979 at Gisborne meat works. Different breeds of cattle were examined for a more detailed study of pigmentation of the eyelid, third eyelid and sclera. The examination was carried out after the head had been severed from the carcase and was being subjected to official inspection by staff of the M.A.F.

The circumocular pigmentation of the skin and hair of the left and right eyes of each animal were examined and classified according to the following categories :

(1) negative;

(2) less than one inch reddish-brown spot;

(3) broken reddish-brown;

(4) reddish brown ring;

(5) broken black, and

(6) black.

Left and right third eyelids were classified into negative and positive for pigment. Sclera of left and right eyes were classified according to the following categories :

(1) negative;

(2) slight at a portion of corneo-scleral junction;

(3) slight around corneo-scleral junction;

(4) distinct, and

(5) abundant.

Data from the second study of pigmentation were entered into AZ64 printed cards to facilitate analysis in which each animal examined was treated as an individual case.

RESULTS

Seven hundred and eighty-four individual case reports of cancer eye were entered onto index cards. The case records were subdivided into 18 meat works of origin. In cases with bilateral lesions, each case was recorded on a separate card but data for other parameters, e.g. breed, age, sex, etc. were recorded on the card for the left eye. The hole on the upper left corner of the index card was cut to distinguish the right eye lesions from a case in which both eyes were affected. Similarity of data written on the front page matched and identified the printed cards used for bilateral cases.

Cards were stacked and arranged according to the ME assigned letter code. Results were obtained by card sorting the values used for the different variables and tallying the score.

Table 1 gives an overall summary of the results based on data from the different meat works. Available figures on cattle kill were entered in the first column. Breed distribution, sex, pigmentation, etc. were extracted by summing the values assigned to the data in the index card. This frequency distribution provided initial results that led to further analysis of information.

Reports from 15 meat works which provided information on the total cattle kill were used to study crude and breed specific rates. Table 2 shows the attack rates in individual works. Seven hundred and fifty-two cases were recorded from a total cattle kill of 843,853 to register an overall crude rate of 89 cases per 100,000 and a specific Hereford-Hereford cross rate of 403 per 100,000 was recorded.

TABLE 2 : CANCER EYE ATTACK RATES

MEAT WORKS	MEAT WORKS NO.	CRUDE RATE per 100,000	H^1+Hx^2 RATE per 100,000
Shortland (Auckland)	24	14	-
Horotiu (Hamilton)	23	34	-
Tomoana (Hastings)	10	48	-
Pacific Meats (Hastings)	52	97	-
Gisborne (Gisborne)	9	242	-
Whakatu (Hastings)	29	57	167
CFM (Christchurch)	15	132	212
Mataura (Invercargill)	21	165	222
Longburn (Palmerston North)	6	60	238
Makarewa (Invercargill)	22	147	397
Balclutha (Dunedin)	26	267	476
Southdown (Auckland)	36	60	520
Feilding (Palmerston North)	32	70	660
Whangarei (Northland)	51	120	746
Oamaru (Dunedin)	18	560	1133
Overall Total		89	403

[1] H = Hereford + [2]Hx = Hereford cross

Initial analysis of crude rates in the North and South Islands, from works from which adequate data were available, showed rates of 58 and 222 cases per 100,000, respectively. When possible adjustments for breed specific rates were made in the calculation (Table 3). Group A included meat works in the North Island that submitted Hereford and Hereford cross estimates in the kill. Group B comprised meat works without such estimates. The Hereford and Hereford cross kill for Group A represented 17.02% of the total cattle kill. Assuming the same percentage of Hereford and Hereford cross were killed at the other works, an estimated kill of 66,556 was arrived at for Group B. Thus a Hereford-Hereford cross attack rate of 343/100,000 was estimated for the North Island and 409/100,000 for the South Island. There is a significant difference between the adjusted attack rates of the two Islands ($P<.05$).

Detailed investigations of eye pigmentation were undertaken. Initially a small study was conducted for a comparative examination of pigmentation of the eyes of Herefords and Hereford crosses. The study was carried out at Feilding and Longburn meat works. The eyelids, third eyelids and sclera were classified as either pigmented or non-pigmented, by gross visual inspection. Eight out of 63 (12.7%) Herefords were found positive for pigmentation on the eyelids. The heads of 36 Herefords, from which previous scores on the eyelids have been made and scored as negative, were examined in more detail at the inspection area and one was found to have a positive third eyelid and sclera. Of 143 Hereford crosses examined 134 (93.7%) had pigmented eyelids. Of 75 Hereford crosses examined 65 (86.7%) had pigmented third eyelids and 72 (96%) had pigmented sclera.

Expressing these results as a ratio of pigmentation in Herefords to Hereford crosses, the ratio for eyelid pigmentation was 1:7, for the third eyelid 1:31 and 1:34 for the sclera (Table 4).

TABLE 3 : ADJUSTED BREED SPECIFIC RATES

MEAT WORKS	TOTAL CATTLE KILL	H*+Hx† KILL	CRUDE RATE PER 100,000	H + Hx RATE PER 100,000
** Group A	295,015	50,200	74	394
***Group B	391,048	66,556	47	276
North Island Works	686,063	116,756	58	343
South Island Works	157,790	82,413	222	409
Overall total	843,853	199,169	89	378

*H = Hereford

†Hx = Hereford cross

** includes Whangarei, Southdown, Whakatu, Feilding, Longburn.

*** includes Shortland, Horotiu, Tomoana, Pacific Meats, Gisborne.

H + Hx kill calculated as 17.02% and assumed to be of the same percentage as Group A estimates.

TABLE 4 : EYE PIGMENTATION OF CATTLE AT FEILDING AND LONGBURN MEAT WORKS

BREED	EYELIDS			THIRD EYELID			SCLERA		
	No.(-)	No.(+)	% Pigmented	No.(-)	No.(+)	% pigmented	No.(-)	No.(+)	% pigmented
Hereford	55	8	12.7	35	1	2.8	35	1	2.8
Hereford X	9	134	93.7	10	65	86.7	3	72	96.0
Pigmentation Ratio		1:7			1:31			1:34	

The accuracy of the visual examination of melanin pigment was assessed by staining wax-embedded sections of the ocular structures of three Herefords and six Hereford crosses by the Masson Fontana staining technique. In both breeds microscopic examination scores coincided with visual inspection scores. Eyelids that showed light brown pigment which were scored positive on clinical examination revealed slight epithelial pigment on histological examination. Those in which the sclera was scored negative showed only slight pigment at the limbus while those that were scored positive had heavy pigment at the limbus.

A wider investigation was carried out at the Gisborne meat works which included 891 head of cattle of different breeds. These consisted of 409 Herefords, 59 Hereford crosses, 328 Angus, 61 Friesians, 26 Murray Grays and 8 Charolais. A summary of the results obtained from examination of the eyelids is shown in Table 5. These eyelids were divided into 15 classes dependent on the degree of pigmentation ranging from completely black skin and hair of all four eyelids to complete absence of pigment.

On examination for pigmentation of the third eyelid, 0.2% of Herefords were found positive, 28.8% of Hereford crosses and 19.7% of Friesians. In the case of other breeds examined 100% were found positive for pigmentation of the third eyelid (Table 6). Table 7 summarises the results of examination of the sclera. Differences in scores recorded from the left and right eyes are shown in Herefords and Friesians.

Attempts were made to investigate the geographical distribution of "cancer eye". The counties of origin of cases submitted for individual meat works were determined and plotted on maps. Cases from different works

TABLE 5 : PIGMENTATION OF THE EYELID OF CATTLE AT GISBORNE MEAT WORKS

CHARACTERISTIC OF EYELID	BREED					
	A	B	C	D	E	F
1. Both eyes encircled in black	-	21	44	328	26	8
2. One eye black,one eye broken black	-	6	1	-	-	-
3. Both eyes broken black	-	7	12	-	-	-
4. One eye black, one eye clear	-	1	1	-	-	-
5. One eye broken black,one eye clear	-	1	-	-	-	-
6. Both eyes encircled in reddish-brown	139	22	-	-	-	-
7. One eye reddish-brown,one eye broken reddish-brown	56	-	-	-	-	-
8. Both eyes broken reddish-brown	118	-	-	-	-	-
9. One eye reddish brown,one eye with spot < 1 in.	7	-	-	-	-	-
10. One eye reddish-brown,one eye clear	5	-	-	-	-	-
11. One eye broken reddish-brown, one eye with spot < 1 in.	8	-	-	-	-	-
12. One eye broken reddish-brown, one eye clear	16	-	-	-	-	-
13. Both eyes with spot less than 1 in.	5	-	-	-	-	-
14. One eye with spot < 1 in., one eye clear	12	-	-	-	-	-
15. Both eyes clear	43	1	3	-	-	-
Total	409	59	61	328	26	8

A = Hereford

B = Hereford Cross

C = Friesian

D = Angus

E = Murray Gray

F = Charolais

TABLE 6 : PIGMENTATION OF THE THIRD EYELID OF CATTLE AT GISBORNE M.E.

BREED	NO. NEGATIVE	NO. POSITIVE	% POSITIVE
Hereford	408	1	0.2
Hereford X	42	17	28.8
Friesian	49	12	19.7
Angus	0	328	100.0
Murray Gray	0	26	100.0
Charolais	0	8	100.0

TABLE 7 : PIGMENTATION OF THE SCLERA OF CATTLE AT GISBORNE M.E.

BREED	EYE	GRADE I	GRADE II	GRADE III	SUBTOTAL I - III	GRADE IV	GRADE V	SUBTOTAL IV - V
Hereford	Left	141	149	92	382	27	0	27
	Right	137	125	120	382	27	0	27
Hereford X	Both	7	2	4	13	15	31	46
Friesian	Left	6	1	0	7	5	49	54
	Right	5	0	0	5	6	50	56
Angus	Both	0	0	0	0	0	328	328
Murray Gray	Both	0	0	0	0	26	0	26
Charolais	Both	0	0	0	0	8	0	8

Grade I Negative

Grade II Slight pigment at corneo-scleral junction

Grade III Slight around corneo-scleral junction

Grade IV Distinct

Grade V Abundant

were represented by different symbols and Figures 2 and 3 illustrate the origin of cases received by three works in the North Island (Figure 2) and three meat works in the South Island (Figure 3).

Meat works "cancer eye" prevalence rates were further related to ratio of dairy to beef animals in the catchment area. The catchment area for a particular works was assumed to consist of the counties of origin of the "cancer eye" cases. Animal population by counties in 1975 (A.J.Mettrick, pers.comm.) was utilised to derive the following dairy to beef ratio :

Whangarei	1:2	Pacific Meats	1:20
Southdown	1:1	Feilding	1:3
Shortland	1:1	Longburn	1:3
Horotiu	1:1	C.F.M.	1.10
Gisborne	1:61	Oamaru	1:18
Whakatu	1:16	Mataura	1:12
Tomoana	1:11	Makarewa	1:10
		Balclutha	1:10

There were 203 carcases that were completely condemned due to the disease. An estimated valuation of the condemned animals, consisting of four bulls, 28 heifers and steers and 171 cows was made from the schedule of beef prices for 1974-5, issued by the New Zealand Meat Producers' Board. The schedule recorded meat prices per kilogram of 32.25, 37.08 and 24.82 for steer, cow and bull. By estimating an average carcase weight of 270, 170 and 300 kilograms, respectively, the loss to the meat industry from condemnation of these carcases was approximately $10,500.

FIGURE 2 : DISTRIBUTION OF CANCER EYE CASES BY COUNTY FROM 3 ME'S IN NORTH ISLAND

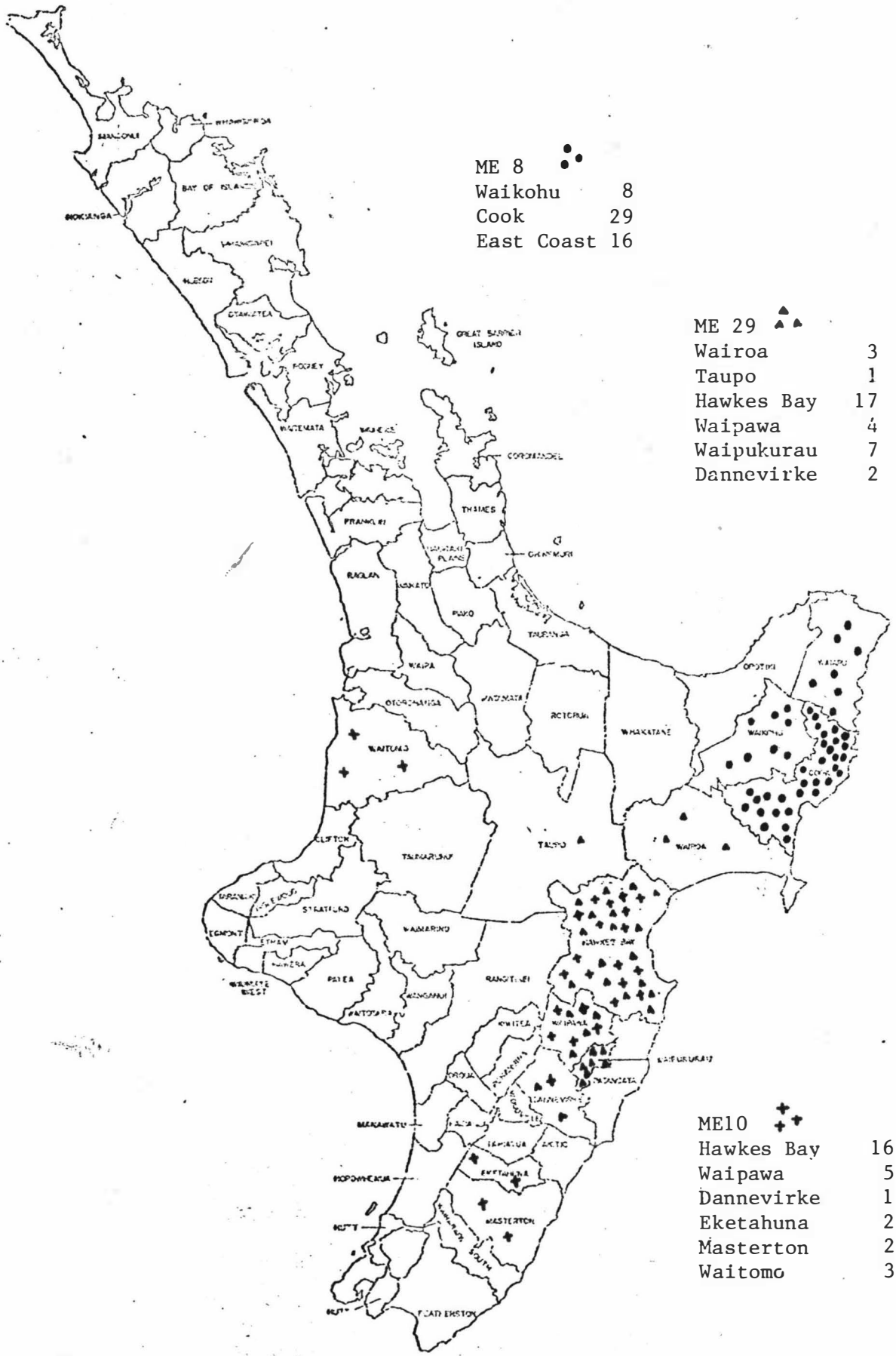
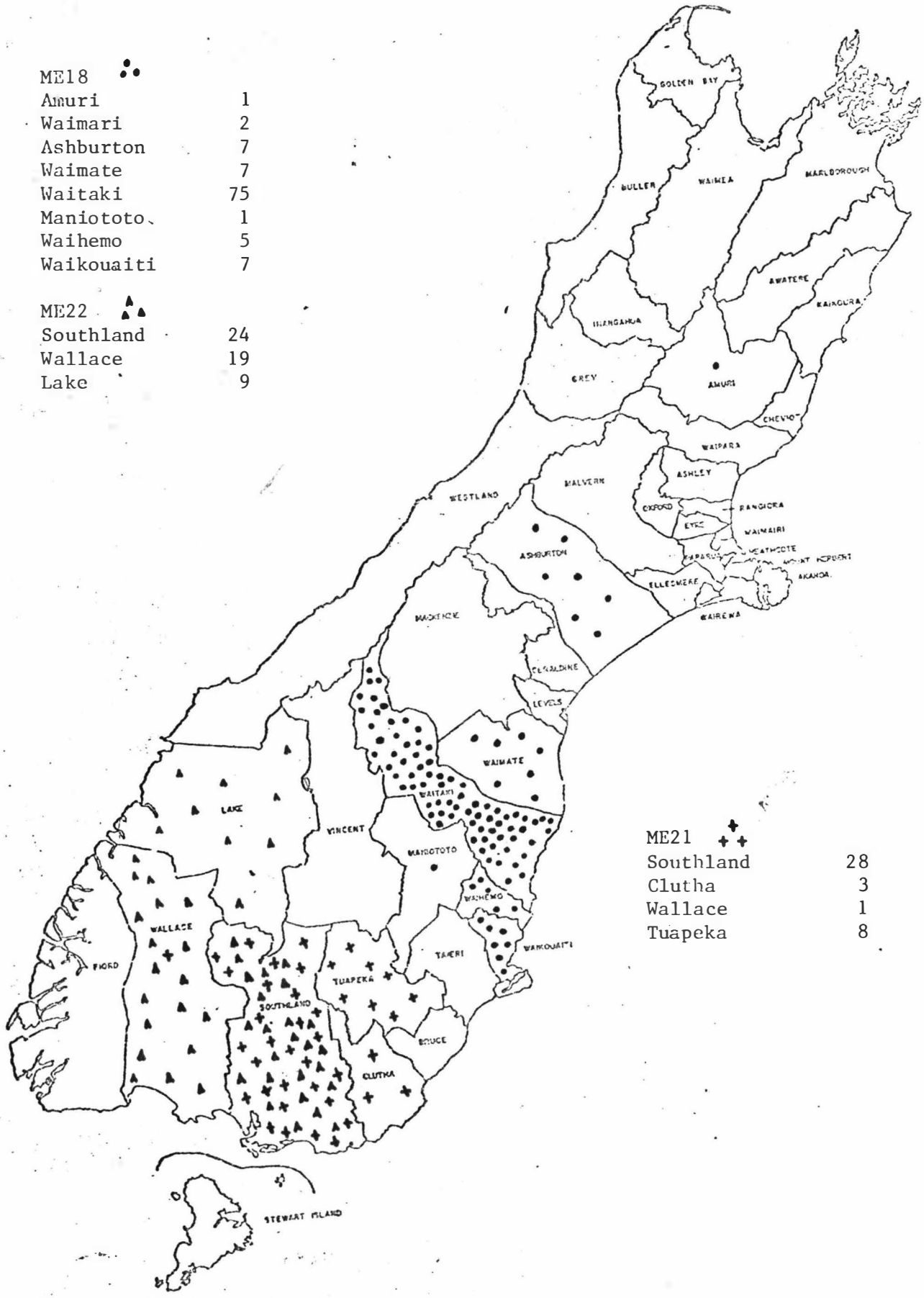


FIGURE 3 : DISTRIBUTION OF CANCER EYE CASES BY COUNTY FROM 3 ME's IN SOUTH ISLAND



DISCUSSION

A. Significance of Findings

1. Breed

The number of animals examined during the survey of "cancer eye" as indicated by the total cattle kill of 843,853 represented 39% of slaughtered cattle in 1975. Of the cases recorded 80.5% were in Herefords, 12.1% in Hereford crosses and 6.4% in other breeds. Herefords and Hereford crosses accounted for 92.6% (726) of the cases. Computation of breed specific rates was possible in ten works where 29.4% of 450,805 slaughtered cattle were Herefords and Hereford crosses. An attack rate of 403/100,000 was recorded in Herefords and Hereford crosses (Table 2) and 8/100,000 in other breeds. These attack rates show that Herefords and Hereford crosses are 50 times more likely to have "cancer eye" than other breeds.

The ratio of Herefords to Hereford crosses was estimated from the June 1976 figures of the distribution of beef cattle in New Zealand furnished by the Economic Service Sheep and Beef Farm Survey. In a survey of commercial beef farms representing 70% of all beef cattle in New Zealand (the remaining 30% are run on beef only farms, dairy beef enterprises, small holdings and government owned farms) the following percentages of Herefords and Hereford crosses were obtained : Hereford - 16%, Hereford x Angus - 25.9%, Hereford x beef Shorthorn - 2.6% and Hereford x other breeds - 1.4% (R.M.Davison, pers. comm.). Hereford crosses represented 29.9%.

These figures provide a breed ratio of 1:1.9 between Herefords and Hereford crosses in the national beef herd. In this study 631 cases were recorded in Herefords and 95 in Hereford crosses, a "cancer eye" prevalence ratio of 6.6:1. If this latter ratio was adjusted in relation to the expected ratio of 1:1.9 between Herefords and Hereford crosses in the beef herd, a

prevalence ratio of 12.54:1 is obtained. This indicates that Herefords are approximately 13 times more likely to have "cancer eye" than Hereford crosses.

These findings support the common belief that as an economic problem "cancer eye" is of importance only to the Hereford breed (Monlux et al, 1957) and confirm the work of French (1959) who showed the striking contrast between the susceptibilities of Herefords and Shorthorns in Queensland. The Hereford-Hereford cross rate of 403 per 100,000 compares with the 180-360 per 100,000 recorded from reviews of M.I.B. slaughtering records in the U.S.A. cited by Hoffman (1978) where more than 90% of slaughtered cattle were Herefords (Russel et al,1956).

2. Sex

A much greater proportion of cases were found in cows (95%). This could not, however, be related to a difference in sex susceptibility because it can be assumed that a greater proportion of animals submitted for slaughter in the older age groups are culled cows. It was probable therefore that age was an important confounding variable.

3. Pigmentation

Eighty-six percent (613) of the cases were found in cattle with non-pigmented eyelids. In relating pigmentation to prevalence it is necessary to establish a scale of measurement of the pigment present. The degree of melanin pigmentation differs appreciably among different breeds, and in the case of Hereford cattle, among individual animals and between each eye of an individual animal.

Recording the score for each eye on a discontinuous scale comprised of 10% units ranging from zero to complete pigmentation, French (1959) measured,

by visual examination, the percentage of pigmented skin at the margin of the lids and pigmentation of the corneoscleral junction of 189 mature Herefords and 150 mature Shorthorns. Anderson et al (1957) described that the skin of the circumocular region of Herefords varies in shade from a yellowish brown to an intense reddish-brown. By photography of the eyes of 105 Herefords and their progeny, he objectively measured the pigmentation by counting the number of units of area in the photographs covered by pigment on a scale which divided lid lengths into 100 equal units. The scores ranged from zero percent for an eye completely devoid of pigment to 100 percent for an eye completely surrounded by pigment and the scores for both eyes were summed to obtain a measure of total circumocular pigment.

In the two small studies described under Materials and Methods, the present author measured pigmentation of the eyelids, third eyelid and sclera of the bovine eye by visual inspection. Both studies showed marked difference in the degree of pigmentation of three structures of the eye in the different breeds examined. The 1:7 eyelid pigmentation ratio found between Herefords and Hereford crosses examined at the Feilding and Longburn meat works demonstrated the marked variation of ocular pigmentation which occurs between these two breed groups. The further study of the 409 Herefords and 59 Hereford crosses examined at Gisborne ME, using the 15 mutually exclusive categories of the characteristics of the eyelid, more accurately showed the contrast in eyelid pigmentation between these two groups. Only in two categories did individual animals of the two breed groups have similar distribution of pigment. Thirty-four percent of Herefords and 37% of Hereford crosses had both eyes encircled in reddish-brown pigment, and 10.5% of Herefords and 1.7% of Hereford crosses had both eyes without any obvious pigment. Thus, this preliminary assessment of ocular pigmentation was not directly comparable to differences in the prevalence of "cancer eye" in the two types of animals.

Eighty-five percent of Herefords from the Gisborne area showed some degree of pigmentation of the ocular structures compared with only 12.7% in the Longburn-Feilding area. This difference may be due to less accurate methods of assessment used in the first study at Feilding-Longburn, or it may be due to true differences of the Hereford population of the two areas.

4. Age

Only eleven percent of the cases were recorded from cattle less than five years old, while the age distribution shown in Table 1 indicates that the disease was encountered mostly in mature cattle. The lack of uniformity in recording age made it difficult to demonstrate any definite correlation of prevalence with age.

5. Site of origin

In agreement with the findings of Monlux et al (1957) and of Russell et al (1956) who also cited the similarity of their findings to that of Steiner and Bengston (1951) and of Wernicke (1935), this survey indicated that the corneoscleral junction is the most common site of origin of "cancer eye". Of 547 lesions whose site of origin could be determined, 45% arose at the corneoscleral junction which approximates to the 50% recorded by Monlux et al (1957) and compares to the 74.8% recorded by Russell et al (1956). Twenty-seven percent of the lesions originated on the eyelids and 28% on the third eyelid. The findings of Monlux et al and Russell et al for the third eyelid were 2% and 7.5% respectively. Both these previous studies also included other specific structures of the eye in the determination of the site of origin (i.e. cornea, caruncle, bulbar conjunctiva, palpebral conjunctiva, limbus, orbital region, lacrimal lake), which were not recorded in the present study.

6. Evidence of malignancy

Of the 744 cases considered, 39% showed evidence of malignancy. These

included 130 cases which were locally invasive without metastases and 161 cases with evidence of metastases in the parotid lymph nodes. Forty-eight of the latter had additional metastatic lesions. Twenty-one of these were recorded in the atlantal lymph nodes, four each in the retropharyngeal and submaxillary lymph nodes and two in the prescapular lymph nodes. A case was recorded to have metastatic lesions in the intra-thoracic oesophagus, one in the liver and another in the lungs. Of the cases with metastases of the atlantal lymph nodes, seven had additional lesions in the submaxillary and two in the retropharyngeal lymph nodes. Of the four cases with metastases in the retropharyngeal lymph nodes one also had metastases in the submaxillary lymph node.

B. An Evaluation of the Survey

The survey has provided relevant information on the prevalence of "cancer eye" in New Zealand. The demonstration of an overall rate of 89 per 100,000 and a Hereford cross rate of 403 per 100,000 indicate that the disease constitutes a definite economic problem. Calculation of the overall rate of "cancer eye" in cattle submitted to New Zealand meat works, for the year in which the survey was carried out, was greater than the overall statistics for all neoplastic condition of cattle by the Meat Division of the M.A.F.!

The total carcase condemnation valued at approximately $10,500 calculated on 1974-5 beef prices, may seem to be insignificant in terms of the total New Zealand meat industry but this does not include animals with lesions too advanced to be submitted for slaughter. Some of the animals submitted for slaughter were treated as suspects at the meat works because of evidence of surgically healed lesions and ablated eyes. This indicates that practicing veterinarians and owners recognise the problem on the farm and probably many affected animals never reach the meat works.

Preliminary studies, before the survey was initiated, had indicated some of the likely epidemiological features of the disease and the probable susceptibility of the Hereford breed. The measurements of the variables recorded in the questionnaire and submitted as individual case report, provided data for analysis. Monlux et al(1957)pointed out that "reports in the literature of cases in other species have been misconstrued by a few writers in recent years as an indication that the problem is equally as great in other species; this is simply not true." In a study of bovine ocular tumours obtained from Denver abattoirs where more than 82% of slaughtered cattle were Herefords, these authors reported that among the 532 cattle with ocular tumours, the breed of 385 was recorded and 378 (98%) were considered to be of predominant Hereford ancestry. Many studies on various aspects of the disease such as, inheritance of susceptibility (Woodward and Knapp, 1950; French, 1959, and Anderson, 1960a), lid pigmentation (Anderson et al, 1957, and French, 1959) and nutritional aspects (Anderson, 1960b) were conducted by observations of herds of Hereford cattle.

In this survey the classification of Herefords and Hereford crosses as a single breed group was a compromise which was not ideal. It was felt that most meat works veterinarians would have found the recording of more precise information to be tedious, if not impossible. A more elaborate evaluation of pigmentation of the eyelid and other structures of the eye would have burdened the examining veterinarian and entailed a more complicated design of the questionnaire.

In studying the location of cases, the 'Locality or Origin' of the survey returns were plotted on maps. Cases from some works showed evidence of clustering. The meat works veterinarian at Oamaru had indicated in his comments that the cases he encountered came from high country. However, there was insufficient data in most cases to establish definite information on location. The map plotting done in Figures 2 and 3 relates cases only

to county of origin and the marks for individual cases do not represent specific locations. The counties represented relate more or less to the extent of the catchment area. For example, that of Gisborne works is the East Coast which draws cattle for slaughter from a fairly definite area. The Tomoana works is shown (Figure 2) to obtain cattle not only from Hawkes Bay but as far south as the Wellington region and as far west as the West Coast of the North Island.

Map plotting also established the overlapping of the catchment areas among works and formed the basis of the estimated dairy to beef ratio of cattle submitted to specific works. It was not possible to relate marked variations of "cancer eye" prevalence rates of 167 to 1133 to geographical location because of two main factors :

(1) the ratio of dairy to beef animals in the catchment areas of the meat works vary from 1:1 to 1:61, and,

(2) the extent of the catchment areas of the meat works vary considerably and overlap each other.

Russell et al (1956) established that "many, but not all, of the benign growth if left untreated will undergo a transformation to carcinoma." These authors showed 'plaque', 'papilloma' and 'cancer' as the progressive sequence of the development of the disease. From histological studies of 830 affected eyes of cattle examined by federal meat inspectors, they found 71.4% to be invasive squamous carcinoma,1.4% carcinoma in situ, 15.7% benign precursor lesions and 11.5% to be not associated with carcinoma.

In the study of 613 tumours found in diseased eyes of 548 cattle from Denver abattoirs, Monlux et al (1957) diagnosed 76.8% as epidermal papilloma and 12.1% as epidermal plaque.

In this survey, out of 37 primary lesions sent for laboratory confirmation

76% were confirmed histologically. Of the 24 metastatic lesions 60% were confirmed. In both cases, the author considered the absence of any results in the case records as an indication of non-confirmation.

The confirmation of 76% of the primary lesions compares with the findings of Russell et al and Monlux et al of 72.8% and 81.7% respectively, where squamous carcinoma and early squamous carcinoma were considered together. It is speculated that those indicated as discrete single lesions, if examined histologically, would have been mostly classified as early squamous carcinoma and benign precursor lesions as described by Russell et al (1956) and Monlux et al (1957).

Manipulation of the data recorded on the index cards yielded information recorded in the Results and discussed above. Most findings were straightforward, as results were based only on single variables and in a few cases, a combination thereof. Some variables have not been considered at all : number of cases in the line, sizes of discrete lesion and local infiltration, and tissues involved in local infiltration, as they were not related to other findings and existing available information on "cancer eye". As a filing system the set of index cards can easily be accessed for reference purposes and/or further analysis. Moreover, data generated from the Gisborne study of eye pigmentation of cattle has been similarly stored in index cards which may find relevance in future work.

CHAPTER II

APPLYING THE COMPUTER IN DATA ANALYSIS

INTRODUCTION

Distinction should be made between the purposes of a research programme and a surveillance programme. It has been stated (Anon, 1968) that research seeks new knowledge from which better control measures may develop, whereas surveillance centres on the application of existing knowledge to control (of disease). It was also suggested that field studies such as multi-purpose serological surveys can be planned in advance, both to produce data and to furnish information in surveillance.

Two serological surveys were conducted in slaughterhouses by the Department of Veterinary Pathology and Public Health. These surveys, one carried out among meat inspectors employed by the Meat Division of the M.A.F. and the other among meat workers, were carried out between 1978-79 in connection with a wider study of abattoir-associated occupational zoonoses in New Zealand. Quite a number of slaughterhouses were involved and returns were obtained from more than 2,000 workers. It was decided to make use of the computer in the analysis of data.

Recent progress in the design and manufacture of computer hardware is impressive. A scientific problem that took an hour on a large 1950 machine at 1,000 operations per second can be run on the fastest contemporary computers in less than half a second and the running time of a program* can be reduced to three or four seconds (McCarthy, 1966).

* a set of instructions to the computer. The American spelling is used to distinguish the technical from the general usage of the word.

Part of the success of the computer can be ascribed to purely economic factors. By lowering the effective cost of calculations the computer has induced a shift towards a greater emphasis on analysis of existing data in many fields where once only experimentation and comparatively simple direct measurements were practical (Oettinger,1966).

The increasing use of computers has given rise to statistical packages. A package program is a programming system available from a supplier (manufacturer or independent software supplier) that comes complete and ready to perform specific tasks.

SPSS, the acronym for Statistical Package for the Social Sciences, is an integrated system of computer programs designed to automate the routine task of data processing and around which a series of other computer programs can be built. The system provides a unified and comprehensive package that enables the user to perform many different types of data analysis in a simple and convenient manner (Nie et al, 1975).

SPSS has been adapted to the Burroughs B6700, the type of computer available at Massey University. Proximity to the Computer Centre and the relatively low charge for computer use, presented enormous advantages. This study applied the system to the analysis of data from the serological surveys of meat inspectors and meat workers.

In applying the SPSS the author was able to make use of the computer system through USERCODE VC0038HARRIS of Dr. R.E.Harris, Department of Veterinary Clinical Sciences,which included the availability of the disk as short access time input medium and the tape as back storage. Computer users may have individualised input mediums. Dr. Harris' disk and tape were recognised by the computer as VC0038HARRIS and VC0255P9HARRIS,

respectively. For simplicity the author refers to them in the text as disk and tape.

A BRIEF BACKGROUND AND GENERAL AIMS OF THE SEROLOGICAL SURVEYS

Workers from two occupational groups at the abattoir were interviewed and a blood sample was obtained from each respondent. The serum from the blood sample was examined for antibodies to Brucella abortus, Leptospira interrogans, Toxoplasma gondii and Coxiella burnetti*. Information was obtained of previous clinical disease associated with these agents and other potential zoonoses. Data were also collected on workers' characteristics such as age, precise occupation, contact with stock etc. (see Appendices III and IV).

Once the data had been organised in a manner suitable for computer analysis (see following sections) attempts were made to ascertain correlations and associations between evidence of previous infection based on the serological tests performed and the possible risk factors associated with work in the abattoir.

Appendix V, a reprint of "The Public Health Significance of Leptospirosis for the Meat Industry" by Professor D.K.Blackmore provides further background information and details of the methodology employed in the conduct of the surveys of the two occupational groups.

* results for Coxiella burnetti were hand-sorted and excluded from computer analysis.

PREPARING SURVEY DATA FOR SPSS INPUT

The data base

Two sets of questionnaire returns from the serological surveys of the meat inspectorate and the meat workers groups were made available as data source documents. These returns were compiled, according to cooperating slaughterhouses, at the Leptospirosis Laboratory, Department of Veterinary Pathology and Public Health. Each set of documents served as a data base for separate statistical analysis. They were identified as the meat inspector file and the meat worker file.

Establishing variables from the files

An individual worker was considered as the basic unit of analysis. The measurements, or variables, made for each worker were extracted from the data base. These measurements were in the form of : (1) questions asked of each worker, and (2) results obtained from the serological tests undertaken on the blood sample. Some of the measurements were combined to establish other variables.

Through requests of Professor D.K.Blackmore directed to the supervising meat inspector, additional data were obtained later in 1979 pertaining to stock slaughtered within the last 10 to 15 years and when slaughter of particular types of stock ceased. Also requested were data on the works at which inspectors had been previously appointed and the duration. Table 8 lists the type of stock slaughtered at present and in the past in all works visited. The information supplied by the supplementary questionnaire was linked to those indicated in the source documents to establish additional variables.

Determining values of variables

Initially, manual sorting of information on returns was done at the

Leptospirosis Laboratory by Dr. Linda Schollum. This sorting showed the format of some of the variables. The values of the other variables were similarly drawn out of the responses to the questions and results of the serological tests. These responses and results determined the parameters of the variables. Some of the variables had discrete numeric values. Others required an arbitrary coding scheme to describe them.

Assigning variables' code names and numeric values

Code names not exceeding eight alphabetic letters were assigned to each variable and numeric values were assigned to responses in which arbitrary coding was required. Assigning of code names and numeric values was made in accordance with the SPSS language (Nie et al, 1975).

Constructing the codebooks

As the meaning of code names and the characteristics represented by numeric values are not always apparent, thorough documentation, in a reference codebook, is essential.

Separate codebooks were constructed for each of the two groups (see Appendices III and IV, Codebook: Serological Survey of Meat Inspectors and Meat Workers, respectively). Each codebook was divided into three vertical sections. The column on the left contained the numbers which located the variables in the records. The second column contained the brief name used to reference the variables in SPSS. The right hand portion contained a detailed description of each variable including a description of the coded values.

Data coding

The task of putting the data into 80-column general-purpose coding forms was undertaken by a laboratory assistant* of the Department

* Jayne Chapman,3rd year student,Faculty of Veterinary Science.

TABLE 8 : STOCK SLAUGHTERED AT THE WORKS

WORKEMP CODE (s)	SHEEP	CATTLE	CALVES	PIGS	GOATS
2	x	x	x	Until 1973	Until 1972
3,12,44	x	x	x	x	-
4,6,24,30	x	x	x	-	-
5,11,15,16,25,27, 31,37,40,47,50,51	x	x	-	x	-
7	-	x	-	Until March 1970	-
8	-	x	-	x	-
9	x	x	x	Until June 1978	x
10,17,19,41,42,48	x	x	-	-	-
13	x	x	x	Until May'78	-
14	x	x	x	-	Until 1969
18	x	x	x	x	Until 1974
20,26	-	x	-	-	-
21,46	x	x	-	Until 1974	-
22	x	x	x	Until 1975	-
23	x	x	x	Until 1971	-
28	x	x	x	Until 1972	Until 1964
29	-	-	-	x	-
32	x	x	x	Until June'77	x
33	Until 1974	x	x	-	-
34	x	Until Sept'75	-	-	-
35,38,45,49	x	-	-	-	-
36	x	x	x	Until 1975	x
39	x	x	x	In "off" season only *	-
43	x	x	-	x	x

* Approximately June to October.

of Veterinary Pathology and Public Health. It was accomplished by working through the two sets of questionnaire returns, using the codebooks constructed for the meat inspector and meat worker files as represented on Appendices III and IV and the listing of stock slaughtered at the works summarised in Table 8. Separate coding files were prepared for the two groups. These files were named INSPECTOR data file and MEATWORKER data file. Checking and editing of the files were undertaken.

Copying the data files onto the input medium

The INSPECTOR and MEATWORKER data files were copied separately by the Computer Centre key-punchers onto the floppy disk*. Upon completion, printouts showing the loaded data were obtained and these were compared with the original files (the coded sheets), to check accuracy in key-punching. Errors detected by the proofing were rectified. From the floppy disk, the data files were copied onto the disk resident in the computer that is accessible via USERCODE VC0038HARRIS.

STORING THE DATA FILES AS SPSS SYSTEM FILES

An SPSS system file is a special file containing the information SPSS needs to identify variables (i.e. variable names, labels, missing values, codes, etc.) as well as the data (Nie et al, 1975).

Preparatory to analysis, the INSPECTOR and MEATWORKER data files were converted into SPSS system files. SPSS programs were written on program work sheets and punched onto tabulating cards in accordance with the directions for using SPSS language (Nie et al, 1975; Anon , 1978b). In the file generating run, the program provided the SPSS with a series of instructions that involved the tasks of naming the variables, specifying their locations in the data records, identifying missing values, providing labels and other related operations.

*floppy disk is a magnetic recording material used at the Computer Centre as an alternative to punched cards for storing data.

Converting the INSPECTOR data file into an SPSS system file

Fifty-five variables were initially established from the serological survey of the meat inspectorate group (see Appendix III). The data files, the filled-in data coding forms and the printouts of the loaded data, were kept for verification of data representation on the input medium. An updated printout was obtained whenever numeric codings were changed.

The data were stored on the disk as MARERO/INSP/DATA. On an initial file generating run the SPSS system organised the data, together with the associated information entered on data definition cards, as MARERO/INSP/SYSTEM. Data definition cards described the data for processing. Example 1 shows the program used to generate the SPSS file.

The printout from this run stated that the file had been saved with 58 variables. Example 2 shows the listing of these variables in ten columns, the file name, indicated as RLLEM, by means of which the file had to be identified in subsequent runs, and the number of cases (1214).

The first three variables in the list : SEQ NUM (sequence number), SUBFILE(subfile structure), and CASWGT (case weight), provided by the output are automatic variables created by the system. These variables go with all SPSS created system files and carry with them important functions that are useful in retrieving certain information from the file (Nie et al, 1975). Inspection of the variables' values indicated in the codebook showed some characteristics that had to be modified. This required the use of data modification cards through which the coding scheme for some variables were transformed and new variables created. They can be created in an SPSS system file by COMPUTE and/or IF statements similar to a program segment as shown on the beginning of page 43.

EXAMPLE 1 : PROGRAM TO GENERATE AN SPSS SYSTEM FILE FOR INSPECTOR DATA.

```
1                16
?BEGIN JOB LEPTOSURVEY;USER=VCOO38HARRIS;CLASS=1;MAXLINES=13000;MAXPROCTIME=500;
?IF FILE MARERO/INSPECTOR/DATA ISNT RSIDENT THEN COPY MARERO/INSPECTOR/DATA
FROM VCO255P9HARRIS:
?RUN SPSS;
FILE FILE8(TITLE=MARERO/INSP/DATA, KIND=DISK, FILETYPE=7);
FILE FILE4(TITLE=MARERO/INSP/SYSTEM, KIND=DISK, FILETYPE=7);
DATA
FILE NAME       RLIEM, FILE FROM PROF BLACKMORE MI LEPTO SURVEY, OCT 1979
DATA LIST       FIXED(1)/1 WORKEMP 1-2, LABREF 3-6, AGE 7-8, SEX 9, RACE 10,
                IMIGRANZ 11, DURIMIG 12-13, NYRINS 14-15, IGRADE 16, WOCONS 17,
                WOCONC 18, WOCONL 19, WOCONP 20, WOCONG 21, DUWOCONS 22-23,
                DUWOCONC 24-25, DUWOCONL 26-27, DUWOCONP 28-29,DUWOCONG 30-31,
                OUCONAGS 32, OUCONAGD 33, OUCONAGB 34,OUCONAGP 35, OUCONAGG 36,
                OUCONS 37, OUCOND 38, OUCONB 39, OUCONP 40, OUCONG 41,
                OUCONDC 42, OUCONHP 43, OUCONHD 44, OUCONHPI 45, SUFLEP 46-47,
                SUFBRU 48-49, SUFTOX 50-51, SUFORF 52-53, LEPHAR 54, LEPPOM 55,
                LEPCOP 56, LEPTAR 57, LEPBAL 58, BRUSAT 59, BRUCFT 60, BRUAHG 61,
                TOXTEST 62, MBLED 63-64, YBLED 65-66, MRBLED 67-68, YRBLED 69-70,
                RLEPHAR 71, RLEPPOM 72, RLEPCOP 73, RLEPTAR 74, RLEPBAL 75
INPUT MEDIUM    DISK
N OF CASES      UNKNOWN
VAR LABELS      NYRINS,YEARS AS INSP/ SUFLEP, SUFFERED LEPTOS
VALUE LABELS    SEX(1)MALE,(2)FEMALE/RACE(1)EUROPEAN,(2)MAORI,(3)ISLANDER
                (4)OTHERS/IMIGRANZ(1)NOT AN IMMIGRANT,(2)FROM EUROPE,
                (3)FROM ELSEWHERE/IGRADE(1)ASSIST. MI,(2)MI,(3)SR MI-TUTOR
                (4)SUPER MI(5)VET (6)OTHERS/SUFLEP(0)NO HISTORY (1)1-5 YRS AGO
                (2) 6-10 YRS (3) 11-15 YRS (4)  15 YRS (5)YRS MISSED (6) NOT
                CONFIRMED
MISSING VALUES  AGE(99)/SEX TO IMIGRANZ (9)/DURIMIG(99)/WOCONS TO WOCONG (9)/
                DUWOCONS TO DUWOCONG(99)/OUCONAG TO CUCONHPI(9)/SUFLEP TO
                SUFORF(99)/LEPHAR TO LEPBAL(9)
READ INPUT DATA
SAVE FILE
FINISH
?END JOB
```

EXAMPLE 2 : SAVING FILE RLLEM.

```
                    SAVE FILE      RLLEM
FILE RLLEM    HAS BEEN SAVED WITH   30 VARIABLES..

SEQNUM     SUBFILE    CASWGT     WORKEMP    LABFLG     AGE        SEX        RACE       IMIGRANZ   DURIMIG
NYRINS     TGRADE     WOCONS     WOCONC     WOCONL     WOCONP     WOCONG     DUWOCONS   DUWOCONC   DUWOCONL
DUWOCONP   DUWOCONG   OUCONAGS   OUCONAGB   OUCONAGL   OUCONAGP   OUCONAGG   OUCONS     OUCOND     OUCONG
OUCONP     OUCONG     OUCONDC    OUCONHP    OUCONRO    OUCONHPT   SUFLEP     SUFBRU     SUFTOX     SUFORF
LEPHAR     LEPPOM     LEPCOP     LEPTAR     LEPBAL     BRUSAT     BRUCFT     BRUAHG     TOXTEST    MBLED
YBLED      MRBLED     YRBLED     RLEPHAR    RLEPPOM    RLEPCOP    RLEPTAR    RLEPBAL

                    THE SUBFILES ARE..

                                  NO OF
                    NAME          CASES

                    RLLEM         1214
```

EXAMPLE 3 : SAVING FILE MWORKER.

```
                    SAVE FILE      MWORKER
FILE MWORKER  HAS BEEN SAVED WITH   74 VARIABLES..

SEQNUM     SUBFILE    CASWGT     WORKEMP    LABREP     AGE        SEX        RACE       IMIGRANZ   DURIMIG
NYRMCAT    MWGRADE    SLASHL     SLACAT     SLACAL     SLAPIG     SLAGOAT    JOBDUR     PMGRADE    PSLASHL
PSLACAT    PSLACAL    PSLAPIG    PSLAGOAT   PJOBDUR    SEPGRAD    SESLSHE    SESLCAT    SESLCAL    SESLPIG
SESLGOAT   SEPJOBDU   WOCONS     WOCONC     WOCONL     WOCONP     WOCONG     SASSOC     CASSOC     PASSOC
OUCONS     OUCOND     OUCONS     OUCONP     OUCONG     OCCON      POCON      OECON      PICON      SUFLEP
SUFBRU     SUFTOX     SUFORF     LEPHAR     LEPPOM     LEPCOP     LEPTAR     LEPBAL     BRUSAT     BRUCFT
BRUAHG     TOXTEST    HPOS       PPOS       CPOS       TPOS       BPOS       LPOS       SHECON     CACON
CALCOK     PIGCON     GOCON      STOCON

                    THE SUBFILES ARE..

                                  NO OF
                    NAME          CASES

                    MWORKER       1250
```

```
1                                16
GET FILE                         RLLEM
COMPUTE                          HPOSI = 1
COMPUTE                          PPOSI = 1
COMPUTE                          CPOSI = 1
IF                               (LEPHAR GT 1) HPOSI=2
IF                               (LEPPOM GT 1) PPOSI=2
IF                               (LEPCOP GT 1) CPOSI=2
```

The numbers 1 and 16 indicate columns in the punched cards. These operations created the three variables HPOSI, PPOSI and CPOSI which are described below.

Fifteen variables were created by transformation of the values of existing variables. PCON represented contact with pigs in and outside the works. It was made to contain the "0" to "5" values and carried the same description as the values of WOCONP (contact with pigs at the works) listed in the codebook. The rest of these variables carried the following descriptions :

BDATE - bleeding date

1 - 12. January to December, 1978

13 - 24. January to December, 1979

RDATE - rebleeding date

1 - 12. January to December, 1978

13 - 24. January to December, 1979

DBLED - interval in number of months, between bleeding and rebleeding dates. Exact values.

DHTIT - difference of hardjo titre between test and retest.

DPTIT - difference of pomona titre between test and retest.

DCTIT - difference of copenhageni titre between test and retest.

DTTIT - difference of tarassovi titre between test and retest.

DBTIT - difference of ballum titre between test and retest.

HPOSI - hardjo combined test results.

1. negative 2. titre $\geq$1:24

PPOSI - pomona combined test results. 1,2 as above.

CPOSI = copenhageni combined test results. 1, 2 as above.

TPOSI - tarassovi combined test results. 1, 2 as above.

BPOSI - ballum combined test results. 1, 2 as above.

LPOSI - all serovars combined test results.

1. negative 2. any of the 5 serovars ≥1:24.

Data not available during the initial file generating run were added to MARERO/INSP/SYSTEM. The data were coded onto forms and copied onto the floppy disk as RMARERO. After editing, these data, which measured three variables, were added to the file through the following program :

```
1               16
GET FILE        RLLEM
ADD VARIABLES   BRSAT, TESTOX, CONCAT
INPUT MEDIUM    DISK
INPUT FORMAT    FIXED (3F1.0)
VAR LABELS      BRSAT, BRUCELLA TEST RESULTS/TESTOX TEST FOR
                TOXO/CONCAT.CAT CONTACT
VALUE LABELS    BRSAT (0) NO TEST (1) <20 (2) 20 (3) 40 (4) 80 (5)
                160 (6) 320(7) 640(8) 1280(8) 2560/TESTOX (1) NO TEST
                (1)< 64 (2) 64 OR >/ CONCAT (0) NO CAT (1) WITH CAT
READ INPUT DATA
SAVE FILE
FINISH
?END JOB
```

A new MARERO/INSP/SYSTEM was created after the addition of variables BRSAT (Brucella standard agglutination test), TESTOX (test for toxoplasmosis) and CONCAT (cat contact). Saving of the file was requested through the SAVE FILE control card.

Converting the MEATWORKER data file into an SPSS system file

Six meat works were involved in the serological survey of meat workers. A total of 1250 cases were obtained from the questionnaire returns. Basically the manner of organising the MEATWORKER data was similar to that of the INSPECTOR data. The original data were stored as MARERO/MEATWORKER/DATA. The SPSS system file created was referred to as MARERO/MEATWORKER/SYSTEM and the file name was called MWORKER.

The program prepared for the initial file generating run contained procedure cards for transformations to create new variables in addition to data definition cards. Thus the saved file appeared as in Example 3. The first three variables in the list indicate the automatic variables followed next by the original variables. The last twelve variables in the list were transformed from the original variables. These carried the following descriptions :

HPOS - hardjo combined test results.
1. negative 2. titre ≥1:24

PPOS - pomona combined test results. 1,2 as above.

CPOS - copenhageni combined test results. 1, 2 as above.

TPOS - tarassovi combined test results. 1, 2 as above.

BPOS - ballum combined test results. 1, 2 as above.

LPOS - all serovars combined test results.
1. negative 2. titre of any of the 5 serovars ≥1:24

SHECON - sheep contact in and outside works.
1. no contact. 2. in contact.

CACON - cattle contact in and outside works. 1, 2 as above.

CALCON- calves contact in and outside works. 1, 2 as above.

PIGCON- pig contact in and outside works. 1, 2 as above.

GOCON - goat contact in and outside works. 1, 2 as above.

STOCON- stock contact in and outside works. 1, 2 as above.

Results of a standard agglutination test performed in connection with examination for brucellosis titres were added into MARERO/MEATWORKER/SYSTEM through the ADD VARIABLES convention. The data were put in as variable BRSAT and carried the same values as BRSAT of INSPECTOR data.

ACCESSING THE SYSTEM FILES

The INSP/SYSTEM and the MEATWORKER/SYSTEM were established as permanent system files. Both were copied onto the magnetic tape that could be

accessed via VCO255P9HARRIS, a back storage facility of USERCODE VCO038HARRIS. Access to either files were made in succeeding SPSS runs by identifying them as MARERO/INSP/SYSTEM and MARERO/MEATWORKER/SYSTEM. Programs were prepared for the manipulation and transformation of variables and their values to establish correlations. Additional programs were worked out to answer questions that were raised from the analysis of results from either the INSPECTOR or MEATWORKER data file.

TYPES OF ANALYSIS PERFORMED

1. Displaying frequency distribution of variables

The first task undertaken in the analysis of data was to determine the pattern of distribution of the cases for each variable in the file. In SPSS this was accomplished through subprogram FREQUENCIES. Example 4 shows the distribution of cases for contact with pigs (WOCONP) and goats (WOCONG) at the works in INSPECTOR file that was derived from the program segment :

```
1                16
GET FILE         RLLEM
FREQUENCIES      INTEGER = WOCONP, WOCONG (0,5)
```

The bracketed numbers after the variables for which frequency counts were desired, indicate the lower and upper code limits. Subprogram FREQUENCIES reports the frequency of occurrence of each unique value detected for a variable. The resulting table presents the raw count of cases for each value, the percentage of cases based on the total number of cases including the missing value (relative frequency), and without the missing value (adjusted frequency) and cumulative frequency.

Special processing options and statistics can be requested by entering the appropriate numbers of the options and statistics on an OPTION card and a STATISTICS card (Nie et al, 1975). In example 5-A, a histogram, the

EXAMPLE 4 : FREQUENCY DISTRIBUTION OF CASES FOR VARIABLES WOCONP (CONTACT WITH PIGS AT THE WORKS AND WOCONG (CONTACT WITH GOATS AT THE WORKS) IN INSPECTOR FILE.

WOCONP

CATEGORY LABEL	CODE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
	0	161	13.3	14.5	14.5
	1	864	71.2	77.6	92.1
	2	52	4.3	4.7	96.8
	3	22	1.8	2.0	98.7
	4	8	0.7	0.7	99.5
	5	6	0.5	0.5	100.0
OUT OF RANGE		101	8.3	MISSING	100.0
	TOTAL	1214	100.0	100.0	

VALID CASES 1113 MISSING CASES 101

WOCONG

CATEGORY LABEL	CODE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
	0	890	73.3	79.7	79.7
	1	137	11.3	12.3	92.0
	2	13	1.1	1.2	93.2
	3	53	4.4	4.7	97.9
	4	6	0.5	0.5	98.5
	5	17	1.4	1.5	100.0
OUT OF RANGE		98	8.1	MISSING	100.0
	TOTAL	1214	100.0	100.0	

VALID CASES 1116 MISSING CASES 98

graphic display of the relative frequencies of the variable's values, was requested through OPTION 8. Mean, standard deviation and variance were requested through STATISTICS 1, 5 and 6, respectively. The OPTIONS and STATISTICS card followed the FREQUENCIES card for variable BRSAT (Brucella standard agglutination test). In the output the histogram of BRSAT's values and the summary statistics directly followed the frequency table (Example 5-A) as shown in Example 5-B.

The characteristics shown by this subprogram are obviously useful without further manipulation. These characteristics also become the basis for subsequent analysis. Information about variable distribution also helps to locate coding and key-punching errors. These errors become evident if certain characteristics appeared which should not have been present. For example, a frequency distribution of variable AGE in the MEATWORKER file showed 13 and 77 years as age of workers and these had to be located and corrected.

2. Measuring association through crosstabulation

A crosstabulation, or contingency table, is a joint frequency distribution of cases as defined by the categories of two or more variables. This technique of investigating relationships is available in SPSS through the CROSSTABS subprogram. A measure of the exact probability of the relationship between the variables is provided by the summary statistic chi-square. This statistic determines whether the variables are independent or related.

Example 6 illustrates the crosstabulation of LEPPOM (pomona titres) and PCON (pig contact in and outside works) in the INSPECTOR file. The categories of LEPPOM are displayed in rows at the left of the table. These categories are arrayed by the categories of PCON, the values of which are indicated on top of the table. The distribution count, and row, column and

EXAMPLES 5-A : PROGRAM SEGMENT REQUESTING FREQUENCY DISTRIBUTION OF VARIABLE BRSAT (BRUCELLA STANDARD AGGLUTINATION TEST), OPTIONS AND STATISTICS, AND PRINTOUT SHOWING FREQUENCY DISTRIBUTION OF BRSAT IN INSPECTOR FILE.

```
FREQUENCIES     INTEGER=BRSAT(1,9)
OPTIONS         8
STATISTICS      1,5,6

FREQUENCIES PROBLEM REQUIRES      55 WORDS OF SPACE
```

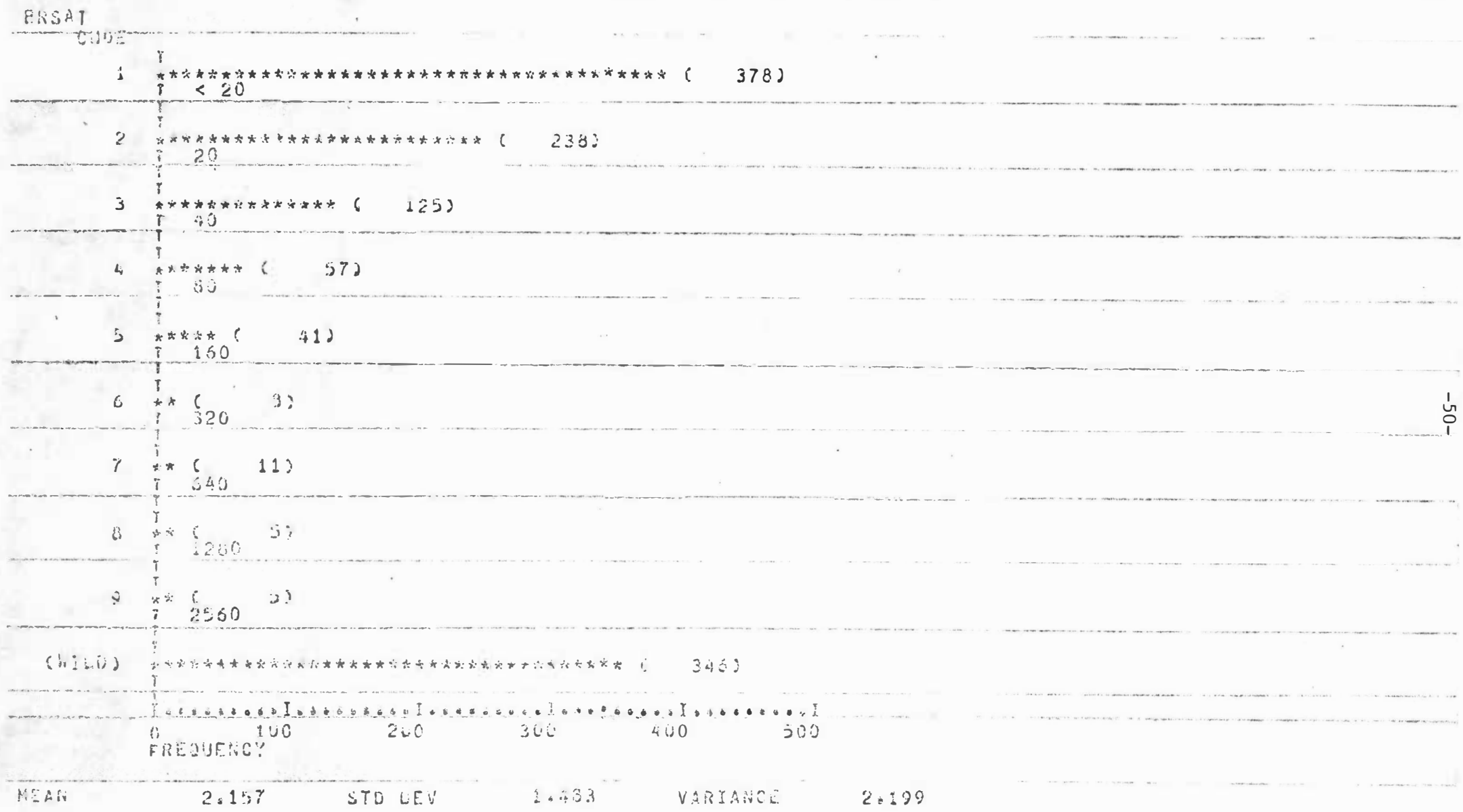
STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES 04/28/80 PAGE 7

FILE RLLFM (CREATION DATE = 04/14/80)

BRSAT

CATEGORY LABEL	CODE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
< 20	1	378	31.1	43.5	43.5
20	2	238	19.6	27.4	71.0
40	3	125	10.3	14.4	85.4
80	4	57	4.7	6.5	91.9
160	5	41	3.4	4.7	96.7
320	6	8	0.7	0.9	97.6
640	7	11	0.9	1.3	98.8
1280	8	5	0.4	0.6	99.4
2560	9	5	0.4	0.6	100.0
OUT OF RANGE		346	28.5	MISSING	100.0
	TOTAL	1214	100.0	100.0	

EXAMPLE 5-B : SUCCEEDING PAGE TO EXAMPLE 5-A SHOWING HISTOGRAM OF BRSAT'S VALUES AND THE SUMMARY STATISTICS FOR BRSAT.



MEAN	2.157	STD DEV	1.483	VARIANCE	2.199
VALID CASES	968	MISSING CASES	346		

total percentages are indicated in that order in each cell of the contingency table. By requesting STATISTICS 1 the summary statistic for chi-square test was printed below the table and included the degrees of freedom and the level of significance.

Categories of variables can be added to simplify the distribution of cases. In Example 7 the values of BRSAT (Brucella standard agglutination test) are reclassified into negative (titre < 1:80) and positive (titre ≥ 1:80) groups. In the data file there were nine categories for this variable. The values of WOCONG (contact with goats at the works) are recoded with value "1" signifying positive goat contact and value "0" being retained as no goat contact.

In crosstabulation, one (or more) variable can be added as a controlling variable. Example 8 is a printout portion of a program run relating three variables : WOCONG, BRSAT and WORKEMP (works of employment). Initially, the categories of each of the variables were classified into two. WORKEMP was made to carry two values : "1" - works slaughtering goats, and "2" - works that did not slaughter goats. WOCONG and BRSAT were reclassified as in Example 7. The CROSSTABS subprogram effected a 2 x 2 table for each of the two values of WORKEMP.

SUMMARY OF RESULTS

The INSPECTOR and MEATWORKER data files carried 76 and 75 variables, respectively. Table 9 shows the number of original, created and additional variables in both files. Three of the original variables : BRUSAT (Brucella standard agglutination test), BRUCFT (Brucella complement fixation test) and BRUAHG (Brucella Coombs test) , were not assigned any values (blanks). Three of the created variables : SEQNUM (sequence number), SUBFILE (subfile structure) and CASWGT (case weight), were automatic variables in SPSS. To display and examine their values, frequency

EXAMPLE 6 : CROSSTABULATION OF VARIABLES LEPPOM (POMONA TITRES) AND PCON (PIG CONTACT IN AND OUTSIDE WORKS) IN INSPECTOR FILE.

* * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * *
LEPPOM BY PCON PIG CONTACT
* *

LEPPOM	PCON: <2 YRS AGO (1)	2-5 YRS AGO (2)	5-7 YRS AGO (3)	8-10 YRS (4)	> 10 YRS (5)	ROW TOTAL
1	315	54	25	11	14	920
	88.0	5.9	2.8	1.2	1.5	92.0
	92.2	94.7	100.0	78.6	73.7	
	81.5	5.4	2.6	1.1	1.4	
2	24	2	0	1	1	28
	85.7	7.1	0.0	3.6	3.6	2.8
	2.7	3.5	0.0	7.1	5.3	
	2.4	0.2	0.0	0.1	0.1	
3	22	1	0	1	1	25
	88.0	4.0	0.0	4.0	4.0	2.5
	2.5	1.8	0.0	7.1	5.3	
	2.2	0.1	0.0	0.1	0.1	
4	9	0	0	1	2	12
	75.0	0.0	0.0	8.3	16.7	1.2
	1.0	0.0	0.0	7.1	10.5	
	0.9	0.0	0.0	0.1	0.2	
5	12	0	0	0	0	12
	100.0	0.0	0.0	0.0	0.0	1.2
	1.4	0.0	0.0	0.0	0.0	
	1.2	0.0	0.0	0.0	0.0	
6	2	0	0	0	1	3
	66.7	0.0	0.0	0.0	33.3	0.3
	0.2	0.0	0.0	0.0	5.3	
	0.2	0.0	0.0	0.0	0.1	
COLUMN TOTAL	858	57	26	14	19	1000
	85.8	5.7	2.6	1.4	1.9	100.0

RAW CHI SQUARE = 42.72919 WITH 20 DEGREES OF FREEDOM. SIGNIFICANCE = 0.0022

NUMBER OF MISSING OBSERVATIONS = 21

EXAMPLE 7 : CROSSTABULATION OF VARIABLES WOCONG (CONTACT WITH GOATS AT THE WORKS) AND BRSAT (BRUCELLA STANDARD AGGLUTINATION TEST) AFTER RECLASSIFYING THE VARIABLES' VALUES IN INSPECTOR FILE

STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

FILE RLLEM (CREATION DATE = 04/14/80)

* * * * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N O F * * * *

WOCONG BY BRSAT

WOCONG	COUNT / ROW PCT / COL PCT / TOT PCT	BRSAT 1 (< 20)	BRSAT 2 (20)	ROW TOTAL
0		545	72	618
		88.3	11.7	78.6
		80.9	64.9	
		69.3	9.2	
1		129	39	168
		76.8	23.2	21.4
		19.1	35.1	
		16.4	5.0	
COLUMN TOTAL		674	111	786
		85.9	14.1	100.0

CORRECTED CHI SQUARE = 13.02650 WITH 1 DEGREE OF FREEDOM. SIGNIFICANCE = 0.0002

NUMBER OF MISSING OBSERVATIONS = 426

distributions of these variables (Table 10) were obtained, exluding the automatic and blank variables, and variable LABREF (laboratory reference number).

The antibody levels to three diseases were determined by laboratory technicians. For leptospirosis, the sera of respondents were tested against five serovars. Results of these tests were coded as LEPHAR, LEPPOM, LEPCOP, LEPTAR and LEPBAL, corresponding to the Leptospira interrogans serovars hardjo, pomona, copenhageni, tarassovi, and ballum, respectively. Each of these variables contained seven values (1 - 7) representing negative and two-fold increasing titres from 1:24.

BRSAT represented the results of a standard agglutination test for brucellosis. A code from 1 to 9 was used to represent increasing titres. A titre of $<$1:20 was coded as "1", 1:20 was coded as "2", 1:40 was coded as "3" and so on, up till code "9".

TESTOX and TOXTEST represented toxoplasmosis test results in the INSPECTOR file and MEATWORKER file, respectively. In both, code "1" was assigned for titres at $<$1:64 dilutions and code "2" for titres at $\geq$1:64.

Variables associated with these titres were related to present and previous contact with different types of stock in and outside the works, contact with other animals, previous history of a clinical illness (i.e. leptospirosis, brucellosis and toxoplasmosis), race, precise jobs etc. (see listing of variables at the codebooks, Appendices III and IV) to demonstrate the risk factors associated with the presence of antibody titres. The strength of their systematic relationships was measured by the chi-square test. Table 10 shows the number of crosstabulations performed for each of these diseases to demonstrate correlations.

EXAMPLE 8 : PRINTOUT PORTION OF A PROGRAM RUN RELATING VARIABLES WOCONG (CONTACT WITH GOATS AT THE WORKS), BRSAT(BRUCELLA STANDARD AGGLUTINATION TEST AND WORKEMP(WORKS OF EMPLOYMENT) IN INSPECTOR FILE.

```
                *RECODE          WORKEMP(2,9,18,32,36,43=1),(ELSE=2)/WOCONG(1 THRU 5=1)/
                                 BRSAT(1 THRU 3=1),(4 THRU 9=2)
                CROSSTABS        VARIABLES=WORKEMP(1,2),WOCONG(0,1),BRSAT(1,2)/
                                 TABLES=WOCONG BY BRSAT BY WORKEMP
                STATISTICS       1

* * * * * * * * * * * * * * * * * C R O S S T A B U L A T I O N  O F * * * * * * * * *
   WOCONG                                                        BY  BRSAT
CONTROLLING FOR..
   WORKEMP                                                       VALUE..     1
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

                  BRSAT
          COUNT   I
        ROW PCT   I< 20      20          ROW
        COL PCT   I                      TOTAL
        TOT PCT   I     1    I     2     I
WOCONG  ----------I----------I----------I
              0   I    79    I     7     I    86
                  I  91.9    I   8.1     I  49.7
                  I  52.7    I  30.4     I
                  I  45.7    I   4.0     I
                ---I----------I----------I
              1   I    71    I    16     I    87
                  I  81.6    I  18.4     I  50.3
                  I  47.3    I  69.6     I
                  I  41.0    I   9.2     I
                ---I----------I----------I
        COLUMN       150          23          173
        TOTAL       86.7         13.3        100.0

CORRECTED CHI SQUARE =      3.10360 WITH 1 DEGREE OF FREEDOM.  SIGNIFICANCE =  0.0781
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

                  BRSAT
          COUNT   I
        ROW PCT   I< 20      20          ROW
        COL PCT   I                      TOTAL
        TOT PCT   I     1    I     2     I
WOCONG  ----------I----------I----------I
              0   I   467    I    65     I   532
                  I  87.8    I  12.2     I  86.8
                  I  89.0    I  75.9     I
                  I  76.2    I  10.6     I
                ---I----------I----------I
              1   I    58    I    23     I    81
                  I  71.6    I  28.4     I  13.2
                  I  11.0    I  26.1     I
                  I   9.5    I   3.8     I
                ---I----------I----------I
        COLUMN       525          88          613
        TOTAL       85.6         14.4        100.0

CORRECTED CHI SQUARE =     13.07592 WITH 1 DEGREE OF FREEDOM.  SIGNIFICANCE =  0.0002
```

TABLE 9 : NUMBER OF VARIABLES IN THE DATA FILES

DATA FILE	ORIGINAL*	CREATED**	ADDITIONAL	TOTAL
Inspector	55	18	3	76
Meatworker	59	15	1	75

* in each file, three variables : BRUSAT(Brucella standard agglutination test), BRUCFT (Brucella complement fixation test), and BRUAHG (Brucella Combs test), were not assigned values.

** in each file, this includes the three automatic variables in SPSS : SEQNUM (sequence number), SUBFILE (subfile structure), and CASWGT (case weight).

TABLE 10 : SUMMARY OF ANALYSIS PERFORMED ON THE DATA FILES

DATA FILE	NUMBER OF VARIABLES EXAMINED FOR FREQUENCY DISTRIBUTION	NUMBER OF CROSS TABULATIONS OBTAINED		
		LEPTOSPIROSIS	BRUCELLOSIS	TOXOPLASMOSIS
Inspector	69	27	40	19
Meatworker	68	83	41	36
TOTAL	137	110	81	55

A total of 110 correlations were carried out to demonstrate the risk factors associated with having titres to Leptospira. Nineteen significant correlations were established. Eight of these indicated the association of titres with history of clinical leptospirosis, three with pig contact in and outside the works, one each with duration of works contact with pigs, outside works contact with pigs and previous pig-associated occupation, two with being a slaughterboard worker and primary processor of carcases and viscera, and three with being employed at works slaughtering pigs.

Of the 81 correlations made with brucellosis titres, 17 were indicated as significant. Five risk factors (true age, time at the works, work contact with cattle, all stock contact at the works, and employment at works that slaughtered goats) each showed a significant correlation. There was a negative association between brucellosis titres and contact with sheep. Two correlations were shown with history of clinical brucellosis. Works contact with pigs and goats showed three and five significant correlations,respectively.

Fifty-five correlations were carried out in relating toxoplasmosis titres to risk factors. No significant occupational associations were demonstrated, neither was there any significant association with cat ownership.

A summary of the more important associations on occupational risk factors determined by these analyses are given in Appendix V (The public Health Significance of Leptospirosis for the Meat Industry by Professor D.K.Blackmore) and Appendix VI (Hazards for Foodborne Infections for Meat Workers by Professor D.K.Blackmore and Dr. L.M.Schollum).

DISCUSSION

Leptospirosis

Significant correlations were established in relating titres to leptospirosis to being employed at works slaughtering pigs, to present and previous contact with pigs in and outside the works, to workers concerned with the slaughter and primary processing of stock, and to a history of clinical leptospirosis. These significant associations are presented and discussed in 'The Public Health Significance of Leptospirosis for the Meat Industry' by Professor D.K.Blackmore (see Appendix V).

Brucellosis

Example 5-A shows the frequency distribution fo BRSAT(*Brucella* standard agglutination test) in meat inspectors. This represents the distribution of brucellosis titres. To determine the titre representing a specific positive reaction to *Brucella* antigen, these measurements, as illustrated in a histogram in Example 5-B, were related to histories of clinical brucellosis. Only a small proportion of inspectors with titres of 1:80 and below had clinical histories with brucellosis and it was therefore concluded that the majority of such titres were non-specific. Although titres of $\geq$1:160 proved to be most specific (i.e. able to detect negative cases), they lacked sensitivity (i.e. ability to detect positive cases). It was therefore decided to take titres of 1:80 and above as the best overall estimate of previous infections. The initial correlations were made with BRSAT (*Brucella* standard agglutination test) having nine categories. These were later reclassified to two, representing negative ($<$1:80) and positive ($\geq$1:80) titres.

With inspectors who handle all classes of stock, it was difficult to correlate specific stock contact with positive titres and no associations

were statistically significant. However, as might be expected there was a negative association with contact with sheep and a positive correlation with cattle. During the initial analysis, several correlations were demonstrated in relating brucellosis titres to stock contact at the works but several of the categories describing the duration of specific stock contact contained less than five cases. When these categories were condensed into fewer options to increase the number of cases within each category, no statistically significant correlations were shown between brucellosis titres and specific stock processed.

Among meat workers, there was a significant association between brucellosis titres and works contact with cattle (P -.004). There was a similar association with pigs.

Among meat workers, a significant correlation was shown with goat contact at the works. Of the six works involved in the survey, two of them slaughtered goats and both were indicated to have ceased slaughtering that species, one in 1964 and the other in 1974. To investigate for confounding factors brucellosis titres were correlated with true age and time at the works. The association of titres with true age was not significant (P -.4148) but titres were shown to be significantly related to time at the works. Since none of the works investigated were still slaughtering goats, the workers in contact with goats would have been in the Meat Industry a number of years. The high prevalence of brucellosis titres among workers with goat contact could therefore be explained by the confounding factor that this group also contained those men who have been at the works for a longer period of time than the general population of meat workers.

Similarly, among meat inspectors, the association between brucellosis

titres and goat contact at the works (Example 7) was highly significant (P - .0002). To investigate for confounding factors brucellosis titres were correlated with two risk factors, goat contact at the works and works of employment. Fifty works were involved in the serological survey of meat inspectors. From Table 8, four works were indicated as presently slaughtering goats and two others slaughtered goats less than ten years ago. These six works were combined as category code "1" to represent the works slaughtering goats and the remaining works were combined as category code "2" to represent works not slaughtering goats. Crosstabulations (Example 8) were performed with three variables : BRSAT (Brucella standard agglutination test), WOCONG (contact with goats at the works) and WORKEMP (works of employment). The test now failed to indicate any significant association with goats (P - .0781), but a highly significant correlation (P - .0002) was established with works that are not slaughtering goats. Inspectors recording goat contact but appearing in WORKEMP category "2" must have previously worked in a works slaughtering goats. Brucellosis titres were further correlated with true age and time at the works. Significant correlations were indicated with true age ($P < .0001$) and time at the works (P - .0085).

Once again, in the meat inspectors' group, the significant correlation of brucellosis titres to goat contact appears confounded by the age and experience of the group recording goat contact.

In both groups, significant correlations were shown in relating titres to brucellosis with time at the works. These suggest strong association of brucellosis titres with longer stay at the works.

Toxoplasmosis

There was no significant difference between prevalence of

toxoplasmosis titres among meat inspectors and meat workers when these titres were compared to a control population of blood donors in 1976 (Appendix VI). No significant association could be found in relating titres with either specific stock contact or cat ownership.

There were three significant correlations with pig contact but these were negative correlations, indicating that toxoplasmosis titres were less likely to be associated with pig contact than with no pig contact.

Among meat inspectors, a significant correlation (P - .0124) was established in relating titres to time at the works. Controlling for true age, a significant correlation (P - .0326) was shown for inspectors in the $\leq$ 40 age group which indicates that presence of titres is associated with a longer stay at the works only among those who are 40 years old and below.

An assessment of the use of the computer

Most of the problems related to the use of the computer in this study were encountered in organising the data. Computer rules must be considered in assigning values to the different measurements undertaken in data collection. Variables had to be extrapolated from answers to questions that had been raised and included in the data base.

Routine interaction with the data obtained from the serological surveys were established through the use of SPSS. The conversion of the data files into SPSS system files provided a ready access to these data and after the SPSS language have been grasped, data handling was limited only by the measurements made on the data base.

Attempts were made to relate serological evidence of a disease to risk factors that were converted into variables. As far as the data

allowed, variables were assigned exclusive and exhaustive categories and were manipulated to establish relationships.

By making use of a package program, the data acquired from the serological surveys of the meat inspectors and meat workers were suitably analysed in the computer. The difficult task of establishing variables could have been minimised if the collected data had been designed beforehand for computer analysis, but, and to a large extent, the ease of access and the capability of the computer to handle data had influenced the extension of this difficult task.

There may well be other statistical packages that can be used for the analysis of data as acquired from the serological surveys of meat inspectors and meat workers, but most of them are designed for experimental data with balanced orthogonal design. The large volume of data obtained from these serological surveys would be difficult to assess using a non-computer based statistical system (e.g. card file, the use of which was described in the first chapter). SPSS is designed for the survey type of investigation and hence is able to cope with large amounts of data.

The ease by which a package program such as the SPSS, can be applied in data analysis puts the onus on the user not to extrapolate too far beyond the reliability of the input data.

CHAPTER III

VITAL STATISTICS FROM MEAT WORKS

INTRODUCTION

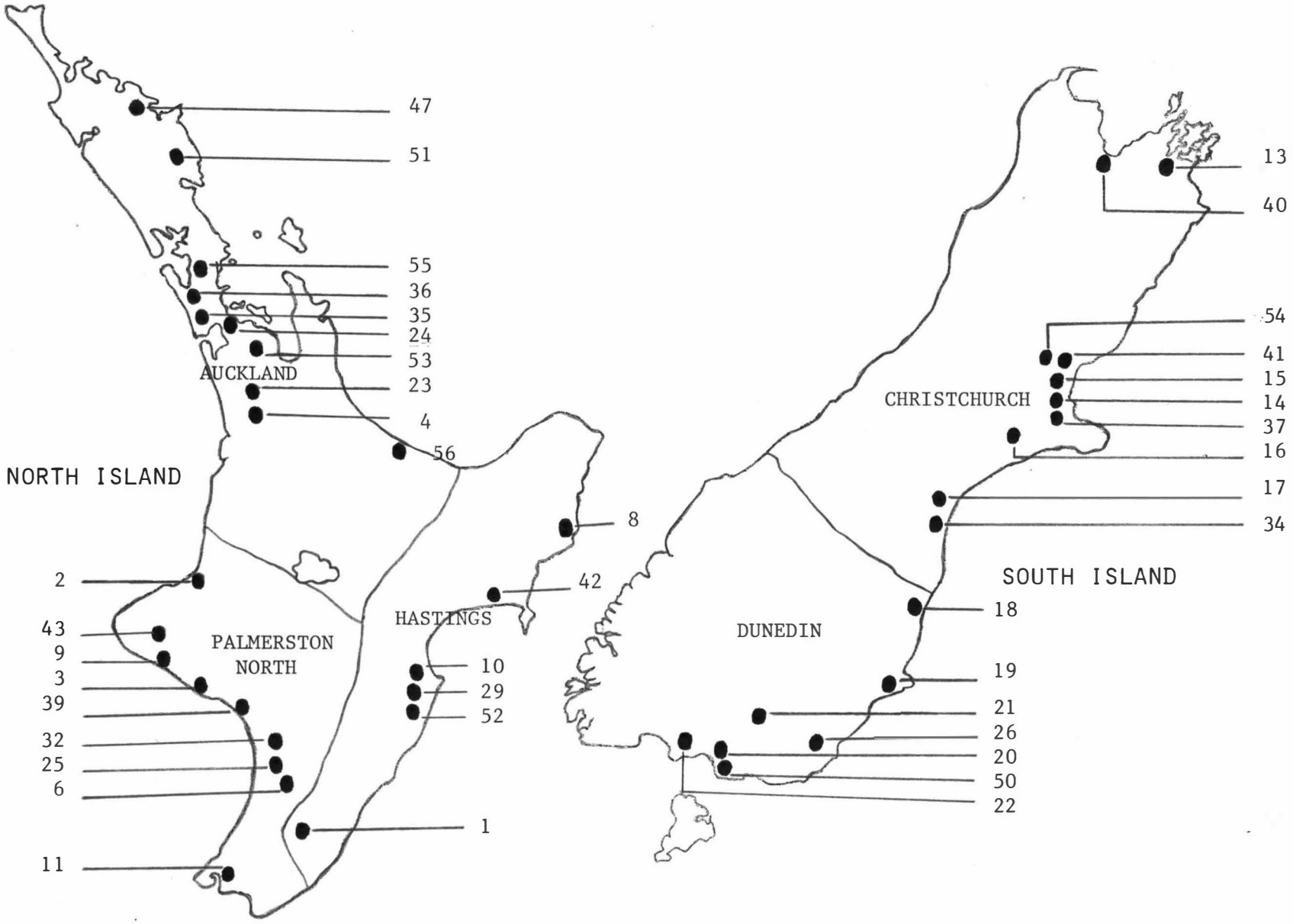
In New Zealand the term meat works has been applied to meat export slaughterhouses. These establishments include not only slaughtering and processing facilities but also provisions for packaging, storage and by-products utilisation. There are 42 meat export slaughterhouses which are distributed throughout both islands (see Figure 4) in addition to a number of local abattoirs, three of which have export licenses.

With only a population of just over three million, New Zealand maintains livestock consisting of 5,580,000 beef and 2,917,000 dairy cattle, 77,962,000 sheep and lambs and half a million pigs (A.J.Mettrick,pers.comm.).Approximately 75% of the total meat production is available for export. Britain, USA, Canada and Japan, in that order, are the major markets. The Meat Industry is by far the largest single earner of overseas funds for the country and during the last few years the export of meat and meat products provided about one third of New Zealand's total export earnings (Petersen, 1979).

To keep major markets open to the Meat Industry, New Zealand pursues a meat inspection system that could be described as expensive and sophisticated. This is not hindered by socio-economic factors and other influences that countries, like the Philippines, have to contend with. Affluent developed countries are willing and able to pay for a safe, wholesome and high quality food product. Thus, food hygiene becomes of relatively greater importance (Petersen, 1979).

Meat inspection is the responsibility of the M.A.F. and is based on the Meat Act 1964 (Anon, 1964) and the Meat Regulations 1969 (Anon,1969). Figure 5

FIGURE 4 : DISTRIBUTION OF 42 MEAT WORKS INDICATED AS M.E. NUMBERS ACCORDING TO REGIONS IN THE NORTH AND SOUTH ISLANDS OF NEW ZEALAND.



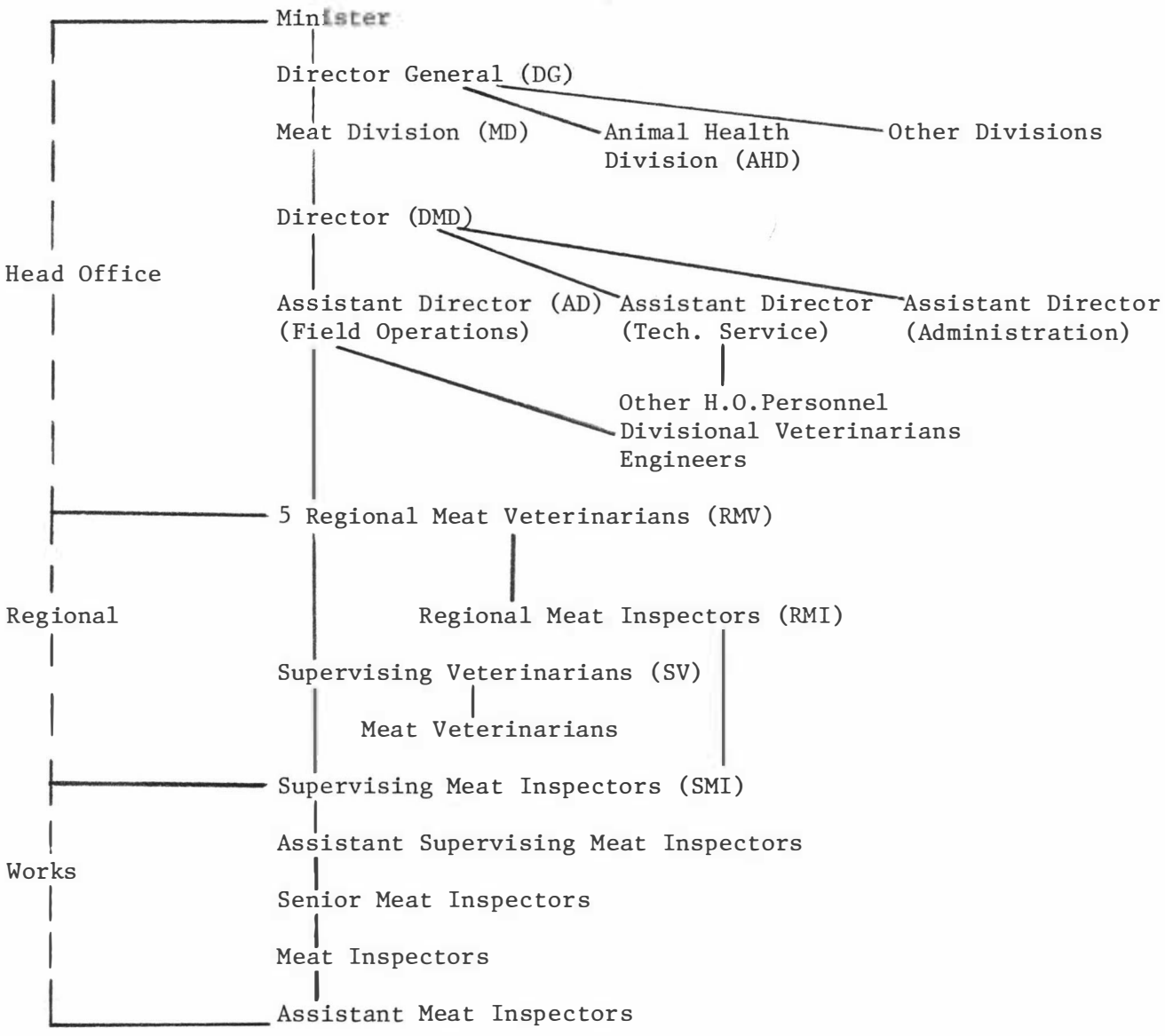
shows the lines of control within the Ministry. In each meat works, the supervising veterinarian is responsible for the standards of meat inspection and hygiene, and monitoring and control of disease. Most of the actual inspection is carried out by meat inspectors trained in the Ministry. Senior meat inspectors are in charge of inspection units (e.g. a beef board or 2-3 mutton chains) and the supervising meat inspector is in-charge of all inspectors at the works. The latter is responsible to the regional meat inspector regarding all staff matters whereas he is responsible to the supervising veterinarian on matters related to meat inspection functions.

As a quality control check on meat inspection procedures the "diseases and defects" system was introduced in 1974 (Christiansen and Hellstrom,1979) to record diseases and condemnation returns from abattoirs and meat works. Eighteen diseases and defects are routinely recorded from cattle, calves, sheep, lambs* and pigs inspected in the establishments. They are : wounds and bruises (WB); emaciation (EMA); pleurisy (PLU); arthritis (ART); pyogenic lesions (PYO); neoplasms (NP); septicaemic-like lesions (SAL); tuberculosis (TB); Cysticercus ovis (C.OVIS); sarcocyst (SAR); caseous lymphadenitis (CLA); actinoform lesions (ACT); xanthoses (XAN); faulty castration (FC); skin lesions (SL); contamination (CONTAM); facial eczema (FEX); and Cysticercus bovis (C.BOVIS). A category "other causes" (OCS) covers any carcase retained or condemned for reasons other than the specific conditions. Each condition has been assigned its own coloured ticket with the disease or defect written on it in abbreviated form. Consecutive numbering on each series of tickets aids counting of animals with each condition.

Systematic post mortem inspection procedures ensure the thorough examination of carcase, head and viscera, from animals passed at ante mortem inspection. On a chain, lambs are processed at the rate of 7-9 carcases per minute and sheep at 5-6 carcases per minute. Inspection is carried out by up to six inspectors. The first carcase inspector palpates

* separate records are made between cattle and calves, and between sheep and lambs. The distinction is placed at approximately one year of age in the case of sheep and lambs.

FIGURE 5 : MINISTRY OF AGRICULTURE AND FISHERIES : LINES OF CONTROL
(after Petersen, 1979)



the ischiatic lymph nodes, half rotates the carcase by giving it a slight twist at the base of the tail, and views and palpates the peritoneal and pleural cavities. The second carcase inspector palpates the other body lymph nodes and the dorsum. Both inspectors make a general appraisal of the entire carcase and attach tickets where appropriate based on their findings.

There are usually three inspectors at the moving viscera table, sharing the inspection of all viscera and the head and tongue. Their findings are verbally communicated to the carcase inspectors. The final meat inspector is at the detain rail re-examining the detained carcases.

For beef up to seven meat inspectors are needed. Two carcase inspectors examine the upper part of the halved carcase on an elevated platform and another inspects the lower parts. One inspector examines the head and tongue, two for the viscera and one at the detain rail. More lymph nodes are examined than in sheep and the chain speed is much slower (usually 25-100/hour). The following lymph nodes are routinely incised : parotid, retro-pharyngeal, submaxillary, atlantal (if present), mediastinal, bronchial, hepatic, superficial inguinal, internal iliac, lumbar chain, renal, and except in prime beef, the prescapular and precrural lymph nodes.

Each of the diseases and defects is recorded by its ticket. If a whole carcase is condemned a condemnation ticket accompanies the other individual diseases and defects tickets. A clerk keeps record of a number of tickets used in each class. Such data form the basis of the M.D. Vital Statistics*. Return sheets are compiled on a daily and monthly basis for each works.

* As defined by Blackmore and Harris(1979) vital statistics is a body of knowledge contained in routinely collected and published data concerning the structure of a population with reference to births, deaths, breed or racial group, diseases, etc.

Monthly statistics are forwarded to the Biometrics Division of the M.A.F. and their analysis results in compilation of regional and national figures.

This study was conducted to determine the usefulness of vital statistics from meat works in epidemiological studies. To establish an estimate of the reliability of routine meat inspection procedures an assessment was initially made of the accuracy of diagnosis of one of the diseases routinely recorded. In the second part of the study an evaluation was made of a one-year summary statistics of the percent prevalence of the diseases and defects recorded at the meat works.

Part A : AN ASSESSMENT OF A RECORDED VITAL STATISTICS AT A LOCAL WORKS - SHEEP ARTHRITIS.

Post mortem inspection has always been regarded as the most important single step in the whole meat inspection procedure. The examination carried out immediately after evisceration offers the inspectorate staff an ideal opportunity for appraisal of carcase and organs before their identities are lost (Petersen,1979).

The objectives set by the M.A.F. for post mortem inspection (Anon, 1978c) are :

1. Remove as a source of human food any carcase, meat or meat product not fit for human consumption;
2. Ensure that stock is slaughtered humanely;
3. Ensure that carcases, meat and meat products are handled hygienically throughout dressing and processing, and
4. Comply with the inspection requirements of customer countries of New Zealand.

At the mutton chain, established guidelines for meat inspection procedures ensure strict adherence to these objectives. Fourteen diseases and defects, including 'other causes', are recorded as carcases move along the chain. One of the conditions that readily lends itself to assessment of its accuracy in meat inspection diagnosis is arthritis. Rules governing the judgment of this disease are contained in Section 16.140 of the M.A.F.Manual No. 16 (Anon, 1978c).

The inspector employs these guidelines and the expertise he acquires from training and experience to identify arthritic joints, along with 13 other conditions. These functions are performed at chain speed and restricted by the fact that suspected joints cannot be opened. This is to prevent contamination with infective material. The suspected joints are tagged for removal at the detain rail.

The objective of this study was to measure the meat inspectors' ability to detect arthritis under practical conditions, i.e. to determine the degree of accuracy in arthritis judgments. Accuracy has two components; sensitivity and specificity (Blackmore and Harris, 1979). The sensitivity of the inspection procedures could only be assessed subjectively as it was not possible to acquire carcases which had been passed unrestricted for detailed examination of joints. However, a small survey was conducted at a local works in order to investigate the specificity of arthritis judgments.

MATERIALS AND METHODS

The collection of material to assess specificity of meat inspection diagnosis in arthritis was carried out at Longburn Freezing Works in January 1980. During that time, the daily kill on the mutton chain started with sheep and lasted until 11.00 am. followed by lambs for the rest of the day.

On three successive visits at the works, condemned joints of sheep that were tagged for arthritis by meat inspectors were gathered from all operating chains. Arrangements were made with the management for the trimmers to put into plastic buckets severed limbs or portions thereof from the detained carcases. They were placed in paper bags and brought to the post mortem room at Massey University immediately after termination of the sheep kill at the works.

The condemned limbs and limb portions were classified into lots according to the joint present. For severed limbs that have two or more joints still intact, only the most proximal joint was examined. Each joint was examined in two stages; firstly for external visible and palpable abnormalities, and; secondly, for internal visible lesions. In external examination the presence of swelling, enlargement and deformities of the joints and around the region of the joints were noted, together with irregularities, i.e. dislocation, fracture, fixation and exostosis.

Thereafter, the joints were opened. Only the more obvious changes of the effusions such as cloudiness, turbidity and discolouration were noted. Lesions on the articular surfaces and bone, and thickening of the synovial capsules were noted for each of the joints.

RESULTS AND DISCUSSION

One hundred and eighteen joints were acquired from Longburn Freezing Works. They were classified into six lots : Shoulder - 10; elbow - 56; knee - 11; hip - 3; stifle - 24; and hock - 14. Table 9 shows the visible and palpable abnormalities on external examination. Abnormalities are grouped as either consisting of swelling and enlargement or with irregularities and exostoses.

TABLE 11: DISTRIBUTION OF EXTERNAL VISIBLE AND PALPABLE ABNORMALITIES OF 118 JOINTS

JOINTS	APPARENTLY NORMAL	SWELLING & ENLARGEMENT	IRREGULARITIES & EXOSTOSES	% WITH ABNORMALITIES
SHOULDER	5	4	1	50.0
ELBOW	1	1	54	98.2
KNEE	1	4	6	90.9
HIP	1	1	1	66.7
STIFLE	2	2	20	91.7
HOCK	2	2	10	85.7
TOTAL	12	14	92	89.8

Table 12 shows the internal visible lesions of the joints examined. Changes either involved the joint capsule, synovial membrane and fluid or the articular surfaces and bone.

Categories of abnormalities in both external and internal examinations were not exclusive groupings. In both instances, a combination of abnormalities, as categorised, may be present in one joint. A joint that was markedly enlarged would not have been as closely palpated as one without. In internal examination, the changes in the joint capsule, synovial membrane and fluid of one which had ankylosis and/or extensive exostosis might have been only cursorily considered. In cases where joints were found to manifest changes in all or the majority of these structures, the structure with the greatest abnormality was recorded for purposes of classification.

Two procedures were employed as diagnostic work-ups to estimate the specificity of meat inspection diagnosis in arthritis. In external examination, 89.9% of the joints were found to have visible and palpable lesions. On internal examination, 90.7% were found to have abnormalities. The failure to observe abnormalities and lesions in the remainder of the 118 joints examined could be attributable to at least three factors :

(1) Judgment in the trimming of arthritic joints. It has been observed that the cut-off points of carcases tagged for arthritis were not consistently marked. In some instances, the trimmer had to ask the inspector for the part of the limb to be cut. This might also have affected the method employed in this study where condemned limbs were classified according to the most proximal joint present.

TABLE 12: DISTRIBUTION OF INTERNAL VISIBLE LESIONS OF 118 JOINTS

JOINTS	APPARENTLY NORMAL	SWELLING & ENLARGEMENT	IRREGULARITIES & EXOSTOSES	% WITH LESIONS
SHOULDER	3	3	4	70.0
ELBOW	1	6	49	98.2
KNEE	2	7	2	81.8
HIP	-	-	3	100.00
STIFLE	2	1	21	91.7
HOCK	3	1	10	78.6
TOTAL	11	18	89	90.7

(2) Inaccurate judgment by the inspector.

(3) Failure by the author to detect any arthritic changes by gross examination.

Based on these observations it is highly probable that there are less than 10% false positives from condemned arthritic joints. Therefore, the specificity of arthritic judgment in meat inspection is high.

Experiences of the author during the conduct of this investigation at the Longburn meat works and other visits at this works and at Feilding and Gisborne meat works, indicate that gross arthritis is not likely to be missed during meat inspection. On these visits, the author observed the strict execution of inspection procedures in no less than 20,000 carcases at the mutton chain. Effective supervision was observed at these works and it ensures the detection of the disease. From these observations it is assumed that sensitivity is also high.

Therefore, on the basis of gross morphological findings found in the condemned joints and experiences at the works, the author contends that there is a high accuracy in the diagnosis of arthritis.

Part B : AN EVALUATION OF THE 1978-79 MEAT DIVISION VITAL STATISTICS FROM MEAT WORKS

The Meat Division Vital Statistics are a compilation of the diseases and condemnation returns from local abattoirs and meat works. Statistics of the routinely recorded conditions have previously been used in epidemiological studies. Such investigations have usually been concerned with a particular disease complex where the investigator attempted to include the available data in field surveys (Kirton *et al*,

1976; McGowan et al, 1978).

However, there appears to be no attempt to evaluate all the data available. This part of the study is concerned with the statistical analysis of the raw data contained in a one-year summary statistics that was supplied by the M.A.F. in order to investigate possible disease trends.

MATERIALS AND METHODS

The M.D. Vital Statistics for the year ending September 30, 1979, was obtained from the M.A.F. The record file provided is a computer printout covering percent prevalence and condemnations of each of the diseases and defects from all meat works. Statistics of each condition are also recorded separately for individual meat export slaugherhouses and for abattoirs.

The statistics of each condition for each kind of stock slaughtered are arranged by meat works. Year to date (YTD) - and monthly mean percent prevalence are arrayed horizontally by M.E. numbers Meat Works are grouped into five regions : Auckland, Hastings, Palmerston North, Christchurch and Dunedin. Data are presented to two decimal places.YTD mean percent prevalence precedes the monthly listing that starts off with October. A national mean percent prevalence is provided at the bottom of the page. Figure 6 shows the format of the M.E. diseases and defects report.

An assessment was made of the percent prevalence of certain diseases and defects from meat works. Selection of conditions to be investigated were based on the following criteria :

FIGURE 6 : FORMAT OF THE DISEASES AND DEFECTS PREVALENCE REPORT

MINISTRY OF AGRICULTURE AND FISHERIES

DISEASES AND DEFECTS

% PREVALENCE ANIMAL SHEEP DISEASE ART FOR YEAR ENDING 30 SEP. 1979

	YTD*	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
AUCKLAND													
HASTINGS													
PALMERSTON NORTH													
CHRISTCHURCH													
DUNEDIN													
NEW ZEALAND													

* Year to date

(1) Conditions with a high prevalence and which therefore could have the greatest economic importance,

(2) conditions that are well-defined and can be easily and appropriately associated with disease, and

(3) conditions presumed not to be affected by processing methods at the works.

To better appreciate the application of these criteria, the lowest and highest values, and means of the percentage prevalence of diseases and defects in sheep, lambs and cattle, were determined from the data in the record file and shown in Table 13.

The conditions selected for statistical evaluation were as follows : arthritis, Cysticercus ovis, caseous lymphadenitis and pleurisy in sheep and lambs, sarcocysts in sheep, and actinoform lesions and pleurisy in cattle. These conditions are among those having the higher prevalence indicated in the statistics. Arthritis is one of the most commonly seen pathological conditions in lambs and sheep in the meat works and causes considerable economic loss because affected carcases have to be either wholly or partly condemned (Kaferstein et al,1972). C.ovis and sarcocysts are well-defined disease conditions and also cause economic losses due to carcase trimming or condemnations. McGowan et al(1978) used pleurisy statistics in a study of enzootic pneumonia-pleurisy complex in sheep and lambs.

Some of the conditions were not selected for this study. Contamination, and wounds and bruises are conditions affected by processing methods at the works (Petersen, 1978; Marshall, 1977). Emaciation, neoplasms, pyogenic lesions, septicaemic-like lesions and 'other causes' are not well-defined

TABLE 13 : MEAT WORKS 1978-1979 VITAL STATISTICS : MEAN, MINIMUM AND MAXIMUM PERCENT PREVALENCE OF DISEASES AND DEFECTS*

DISEASES AND DEFECTS	SHEEP		LAMBS		CATTLE	
	MEAN	MINIMUM and MAXIMUM	MEAN	MINIMUM and MAXIMUM	MEAN	MINIMUM and MAXIMUM
ARTHRITIS	2.06	1.02-5.89	0.93	0.48-1.80	0.56	0.20-1.77
CYSTICERCUS OVIS	4.45	0.81-7.74	0.40	0.10-0.85	-	-
CASEOUS LYMPHADENITIS	5.30	0.73-17.23	0.43	0.12-0.89	-	-
CONTAMINATION	15.07	6.30-24.78	10.16	5.20-15.95	7.12	1.11-16.10
EMACIATION	0.92	0.18-2.56	0.01	0.01-0.02	0.09	0.00-0.68
FACIAL ECZEMA	0.02	0.00-0.11	0.01	0.00-0.04	0.11	0.00-1.39
NEOPLASMS	0.81	0.35-2.15	0.01	0.00-0.02	0.10	0.01-1.50
PLEURISY	24.97	11.65-47.72	3.14	0.84-8.05	2.59	0.66-10.26
PYOGENIC LESIONS	0.91	0.45-1.86	0.15	0.09-0.27	0.55	0.21-1.11
SEPTICAEMIC-LIKE LESIONS	0.14	0.03-0.43	0.02	0.01-0.04	0.06	0.01-0.17
SARCOCYSTS	7.32	0.72-17.61	0.01	0.00-0.02	-	-
TUBERCULOSIS	0.00	-	0.00	-	0.17	0.00-1.98
WOUNDS & BRUISES	2.72	0.75-8.76	1.16	0.44-3.03	5.99	1.47-20.37
ACTINOFORM LESIONS	-	-	-	-	0.89	0.07-1.88
CYSTICERCUS BOVIS	-	-	-	-	0.01	0.01-0.05
XANTHESES	-	-	-	-	0.04	0.00-0.17
OTHER CAUSES	4.10	1.03-7.32	0.94	0.23-2.81	2.15	0.43-5.19

* Underlined conditions for the corresponding species were selected for statistical analysis.

disease conditions. Facial eczema, tuberculosis, Cysticercus bovis, pigmentation, arthritis in cattle,and sarcocysts in lambs, have a very low prevalence.

Disease statistics of pigs and bobby calves* were excluded from evaluation. Relatively low numbers of pigs are slaughtered. They are generally slaughtered in local abattoirs and in recent years some works have phased out slaughter of this species (see Table 8 , Chapter II). In the case of bobby calves there were very few disease conditions found during meat inspection which is not surprising, considering that these are only a few days old when slaughtered.

The YTD mean percent prevalence of each of the selected conditions were set up for the application of single classification analysis of variance (anova) as described by Sokal and Rohlf (1969). Example 9 shows the anova computations of the prevalence statistics of arthritis of sheep. YTD percent prevalence of the five regions are arranged vertically in the upper half of the table, each group consisting of the meat works in a region. The sum of the statistics in each region is in the next row under the horizontal line. The mean of each region is in the next row followed by the sum of the squared prevalence of the works under each region. The last row shows the number of meat works in each region. The grand mean and the grand totals are shown in the lower right column. The computational steps are listed below the table.

* a few days old calves submitted for slaughter.

EXAMPLE 9: ANALYSIS OF VARIANCE COMPUTATIONS OF PERCENT PREVALENCE OF ARTHRITIS OF SHEEP (after Sokal and Rohlf, 1969)

	REGION					
	AUCKLAND	HASTINGS	PALMERSTON NTH.	CHRISTCHURCH	DUNEDIN	GRAND TOTAL
% Prevalence of meat works	1.82	3.00	2.02	1.33	1.09	
	1.70	3.78	1.90	3.50	1.76	
	1.71	2.30	2.41	1.75	1.52	
	1.17	2.84	1.89	1.02	1.24	
	2.19	5.89	3.11	1.03	1.45	
	1.48		2.28	2.39	3.01	
	2.13			2.67	1.68	
				1.86		
TOTAL	12.2	17.81	13.61	15.55	11.75	70.92
MEAN	1.743	3.562	2.268	1.944	1.679	2.149 (GRAND MEAN)
SUM OF SQUARES	22.019	71.336	31.941	35.483	22.119	182.898
No. of MEAT WORKS	7	5	6	8	7	33

Computational Steps :

1. Grand total = 70.92

2. Sum of all squared percent prevalence = 182.898

3. Sum of the squared regional totals, each divided by the number of works within regions = $\frac{(12.2)^2}{7} + \frac{(17.81)^2}{5} + \frac{(13.61)^2}{6} + \frac{(15.55)^2}{8} + \frac{(11.75)^2}{7} = 165.523$

4. Correction term = Grand total squared/total number of meat works = $\frac{(70.92)^2}{33} = 152.414$

5. SS (Sum of squares) total = Quantity 2 - Quantity 4 = 182.898 - 152.414 = 30.484.

6. SS among regions = Quantity 3 - Quantity 4 = 165.523 - 152.414 = 13.109

7. SS within regions = Quantity 5 - Quantity 6 = 30.484-13.109 = 17.375

To obtain the mean squares (MS) the sum of squares (SS) was divided by the corresponding degrees of freedom (df). Four df were noted among regions, there being five regional groupings, and 28 df noted within regions these being the sum of 6, 4, 5, 7 and 6 degrees of freedom in the five regions. The sum of squares represents the deviations of the regional means from the grand mean. The mean squares is the mean variance of the prevalence of meat works.

Variance ratio (Fs) of arthritis of sheep was obtained by dividing MS among regions, by MS within regions. The resultant ratio is compared to the F-distribution table (Gomez and Gomez, 1976) to determine its probability level.

Similar computations were carried out for the statistical analysis of the data of C.ovis, caseous lymphadenitis, pleurisy, and sarcocysts of sheep, arthritis, C.ovis, caseous lymphadenitis, and pleurisy of lambs, and actinoform lesions and pleurisy of cattle. In the two diseases of cattle the 28 df noted within regions was obtained from the sum of 7, 5, 7, 4 and 5 degrees of freedom in the five regions. Some of the meat works that slaughtered sheep and lambs did not slaughter cattle and there were works that slaughtered cattle which did not slaughter sheep and lambs.

Computations for the statistical analysis of the data were performed on a small standard calculator with one memory. These computations were recorded and checked using a programmable calculator, TI Programmable 59*. This handheld calculator is provided with modules and the one-way analaysis of variance could be performed using the program from the Applied Statistics module.

* manufactured by Texas Instruments, Inc., USA.

RESULTS

Analysis of variance was applied to the recorded statistics of eleven diseases of sheep, lambs and cattle. Of the five diseases of sheep evaluated, four diseases: arthritis, caseous lymphadenitis, pleurisy and sarcocysts, showed significant ($P < 0.01$) regional variations (Table 14). In the case of Cysticercus ovis , a variance ratio of 2.31 was obtained. From the F-distribution table, such a value is expected in between 5% and 10% of cases with(4/28)degrees of freedom, that is, $0.05 < P < 0.10$.

Arthritis and pleurisy of lambs showed significant ($P<0.01$) regional variations (Table 15). The variance ratio of 2.69 obtained in caseous lymphadenitis compares with the Fs value 2.71 of the F-distribution table at the 5% level. No significant regional variation was found in Cysticercus ovis ($P > 0.05$).

Significant regional variations ($P<0.01$) were found in actinoform lesions and pleurisy of cattle (Table 16).

The means and their standard deviations of regional percent prevalence of the diseases evaluated for sheep, lambs and cattle are shown in Tables 14, 15 and 16, respectively. These percentages of prevalences are illustrated in a series of histogram blocks in Figure 7.

DISCUSSION

Percentage figures were used in this analysis. The computed regional means were not true means but were the average of the individual percentages recorded from works within a region. Total kills of sheep in 24 works were between 100,000 and 300,000. Six of the meat works

TABLE 14 : REGIONAL MEANS AND THEIR STANDARD ERRORS OF PERCENT PREVALENCE OF ARTHRITIS, CYSTICERCUS OVIS, CASEOUS LYMPHADENITIS, PLEURISY AND SARCOCYSTS OF SHEEP.

DISEASE	AUCKLAND	HASTINGS	PALMERSTON NTH.	CHRISTCHURCH	DUNEDIN	P-VALUE
ARTHRITIS	1.74	3.56	2.27	1.94	1.68	< 0.01
	±0.13	±0.63	±0.19	±0.31	±0.24	
CYSTICERCUS OVIS	4.39	5.53	5.33	4.49	3.42	> 0.05
	±0.48	±0.81	±0.36	±0.55	±0.49	
CASEOUS LYMPHADENITIS	1.09	2.23	2.49	10.17	6.93	< 0.01
	±0.05	±0.42	±0.56	±1.68	±1.70	
PLEURISY	32.53	33.93	29.02	17.17	18.59	< 0.01
	±3.46	±3.30	±1.52	±1.03	±1.22	
SARCOCYSTS	2.10	9.02	11.18	4.44	7.65	< 0.01
	±0.48	±1.06	±1.93	±0.85	±2.02	

TABLE 15 : REGIONAL MEANS AND THEIR STANDARD ERRORS OF PERCENT PREVALENCE OF ARTHRITIS, CYSTICERCUS OVIS, CASEOUS LYMPHADENITIS AND PLEURISY OF LAMBS.

DISEASE	AUCKLAND	HASTINGS	PALMERSTON NTH.	CHRISTCHURCH	DUNEDIN	P-VALUE
ARTHRITIS	0.78 ±0.07	1.27 ±0.15	0.82 ±0.10	0.84 ±0.07	0.93 ±0.05	<0.01
CYSTICERCUS OVIS	0.46 ±0.07	0.57 ±0.12	0.54 ±0.07	0.34 ±0.07	0.31 ±0.05	>0.05
CASEOUS LYMPHADENITIS	0.28 ±0.04	0.50 ±0.10	0.46 ±0.07	0.36 ±0.04	0.49 ±0.06	>0.05
PLEURISY	4.92 ±0.57	5.26 ±0.88	3.37 ±0.44	1.78 ±0.22	2.15 ±0.24	<0.01

slaughtered less than 100,000 and three slaughtered more than 300,000. Thus, there was a large denominator population at each works and these percentage calculations are likely to be a true indication of mean prevalences.

Figure 4 shows the regional distribution of the 42 meat works in New Zealand. Three regional groupings are established for the North Island: Auckland, Hastings and Palmerston North; and two for the South Island: Christchurch and Dunedin. An attempt was made below to relate the information derived from the YTD prevalence statistics of each of the diseases analysed, to geographical prevalence.

Ovine arthritis

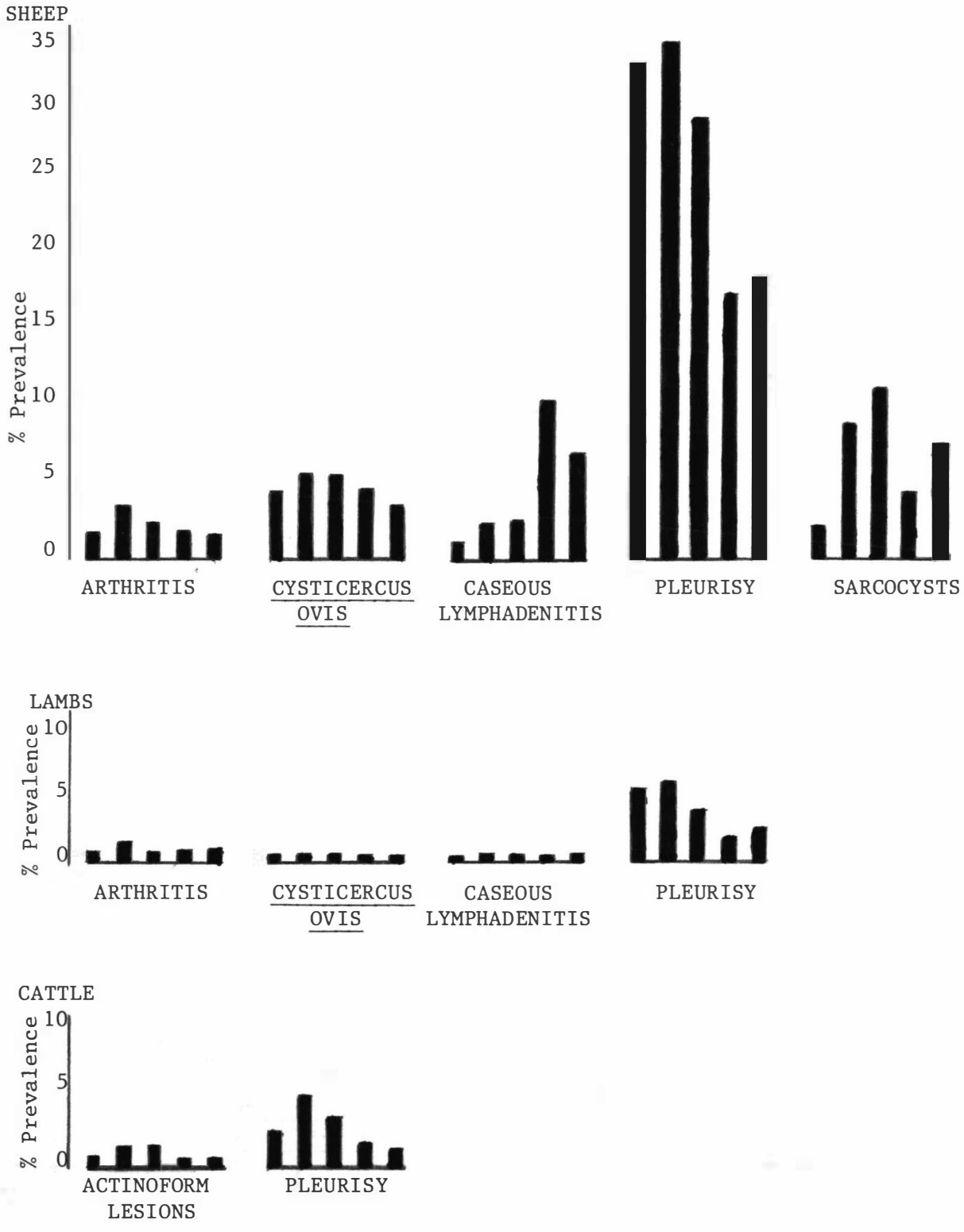
The results of investigations presented in the first part of this chapter indicated a high specificity of diagnosing arthritis during routine inspection of sheep carcases. A similar test applied to lambs might have shown a lower specificity than the 89.9 to 90.7% found in sheep because lesions from condemned joints of lambs might have been less obvious on gross examination. However, similar procedures are carried out for both and it is presumed that the accuracy of diagnosis of arthritis of lambs is approximately the same for sheep.

Significant regional differences were obtained for sheep and lambs. The Hastings region showed the highest regional means in both cases. The means of the other regions vary only slightly from each other although in sheep, Palmerston North showed a higher prevalence than the other three regions.

TABLE 16 : REGIONAL MEANS AND THEIR STANDARD ERRORS OF PERCENT PREVALENCE OF ACTINOFORM LESIONS AND PLEURISY OF CATTLE

DISEASE	AUCKLAND	HASTINGS	PALMERSTON NTH.	CHRISTCHURCH	DUNEDIN	P-VALUE
ACTINOFORM LESIONS	0.81 ±0.19	1.14 ±0.11	1.32 ±0.11	0.47 ±0.08	0.53 ±0.13	< 0.01
PLEURISY	2.26 ±0.23	4.75 ±1.52	3.22 ±0.29	1.69 ±0.23	1.18 ±0.19	< 0.01

FIGURE 7 : REGIONAL PERCENT PREVALENCE OF SOME DISEASES OF SHEEP, LAMBS AND CATTLE*



* regions from left to right in all blocks are Auckland, Hastings, Palmerston North, Christchurch and Dunedin.

Comparisons of means between sheep and lambs in each region showed that arthritis of sheep is about 2-3 times more prevalent than that of lambs. This is a reasonable indication of increased prevalence due to exposure with age.

A survey aimed at assessing sheep farmers' opinion on the relative importance of a range of diseases was implemented by the M.A.F. in the autumn and winter of 1975. A postal questionnaire was forwarded to approximately 1600 sheep owners asking them to nominate each of 17 "disease" conditions as "non-existant", "present-no problem", "moderate problem" or "serious problem" in their flocks. This was followed by having 600 of these farmers interviewed and the farmers were asked to nominate in order of importance, the four most serious diseases from the same list as they received in the post (Simpson,1976). Results from that survey indicated that arthritis is ranked third among the most serious conditions listed (Simpson, 1976; Anon, 1975). The present study appears to indicate that arthritis is particularly important in the lower part of the North Island.

Cysticercus ovis

Table 13 shows a mean prevalence of 4.45% in Cysticercus ovis in sheep and 0.40% in lambs. It may be assumed that inspection of C.ovis will be reasonably precise (i.e. repeatable) as the cyst should be easy to distinguish from other diseases and defects. However, it is probably not very accurate as many deep-seated cysts will be missed (McNab and Robertson, 1972) but it may be assumed that the same proportion will be missed by all inspectors.

Taenia ovis, the adult form of Cysticercus ovis in the final host, is concurrently under a control programme together with Echinococcus

granulosus (the true hydatid) and Taenia hydatigena (the false hydatid) by the National Hydatids Council. All three tapeworms occur in the dog and as far as is known this animal is the only primary host in New Zealand (Gemmel, 1961). Taenia ovis was brought under the definition of hydatids as mentioned by Thomson (1975) because of its overlapping "ecological niche" with the other two parasites (Harris, 1980).

The progress of the eradication campaign of Taenia ovis could be monitored through the prevalence levels of Cysticercus ovis found at the works. In this study, the insignificant regional differences of mean prevalences of C. ovis in both sheep and lambs from the analysis of meat works statistics indicate a uniform prevalence of T. ovis in dogs in the different regions. However, analysis of individual works might detect area differences as is known to occur in E. granulosus in dogs.

Caseous lymphadenitis of sheep and lambs

Analysis of Meat Division records (Anon, 1979) obtained from five killing seasons covering 1974 to 1979 showed an increasing prevalence of caseous lymphadenitis of sheep and lambs. It was also indicated that South Island has had, traditionally, a higher prevalence of this disease than the North Island. Differences in climatic conditions, managerial approach and meat inspection procedures were cited as possible explanations to the different prevalence levels in the two islands.

Dayus (1953) reported that in Southland, a province in the South Island, the maximum levels of stocking frequently occur and that pastures are extremely bare in winter for upwards of four months.

In this analysis, a significant regional difference was shown for caseous lymphadenitis of sheep. The means of the two South Island regions

are much higher than the means of the three North Island regions, Auckland being the lowest (Table 14 and Figure 7). The statistical test used did not show significant regional variation in the case of lambs. The higher means of the South Island regions indicate the presence of factors in that Island, possibly more adverse weather conditions and higher stocking densities, that might account for the differences in disease prevalence of sheep.

A comparison of the regional means showed that caseous lymphadenitis of sheep is 4-5 times more prevalent than that of lambs in the North Island. In the South Island, it is 14 and 28 times more prevalent in sheep than lambs in the Dunedin and Christchurch regions respectively.

Observations by the author of meat inspection procedures at a few works, indicate that they are likely to have a high accuracy of diagnosis of caseous lymphadenitis. Ovine tuberculosis, reported as having a nil prevalence (Table 13), might have presented a problem of differential diagnosis.

Pleurisy of sheep, lambs and cattle

Significant regional differences in pleurisy were established for sheep, lambs and cattle. These significant differences are attributed to higher prevalences in the three North Island regions. Generally, the trend in cattle is similar to that of sheep and lambs.

McGowan *et al* (1978) and Dysart (1976) analysed Meat Division records of pleurisy of sheep and lambs from the 1974-75 killing season and indicated the substantial magnitude of difference in pleurisy of both sheep and lambs between the North and South Islands. No explanation was given for the higher prevalences in the North Island.

Figure 7 shows an identical trend in the histogram representations of prevalences of pleurisy between sheep and lambs in the five regions. The order of prevalence of pleurisy of sheep among regions is the same as that of lambs.

Computing the ratios of the regional prevalences of sheep (Table 14) to lambs (Table 15) gave results of 6.6, 6.5, 8.6, 9.7 and 8.7 for Auckland, Hastings, Palmerston North, Christchurch and Dunedin, respectively. These figures quantify the relative risks of sheep and lambs in the respective regions. Kirton et al (1976) showed that lambs may have subclinical lesions of pneumonia as early as 45 days of age and assumed that pleural adhesions are sequelae to pneumonia. McGowan et al (1978) indicated that the increasing prevalence of enzootic pneumonia-pleurisy in the lamb population may be a function of increasing exposure with age. A hypothesis that could be advanced from the information provided by the computed ratios is that at Christchurch, a greater proportion of "younger" lambs are brought to the works than at Auckland or Hastings, or that lambs from the Christchurch region acquire the disease at a later stage in life.

Sarcocysts of sheep

A significant difference between means of regions was obtained in the analysis of prevalence of sarcocysts of sheep. The measure of prevalence records the macroscopically visible and detectable cysts observed at meat inspection. There are three species of Sarcocystis in sheep, two of which give rise to macrocysts detectable at meat inspection; the third is microcystic and dog-derived. The macrocystic species are both cat-derived (Collins et al, 1979).

In the light of these findings, it can be assumed therefore that the

recorded prevalences reflect the levels of macrocystic infection of sheep brought to the works which were indicated to be much higher in Palmerston North and Hastings as compared to Auckland, and somewhere in between in the two South Island regions (Table 14 and Figure 7). Regional differences might have been due to differences in inspection procedures in these regions. Detection of sarcocysts presents some difficulties because of its subjective nature and it is likely that nearly 100% of adult sheep are infected with either macrocysts and/or microcysts (G.H.Collins, pers.comm.). Meat inspection is subjected to scrutiny on a regional basis by the Regional Meat Veterinarian. It would therefore not be unexpected to find different standards not only between works but also between regions.

Close examination of the recorded prevalences revealed that :

(1) The Auckland region has the lowest prevalence between regions. Within Auckland, two works showing the higher prevalences have catchment areas likely to be adjacent to those of the works from the other two regions in the North Island with higher means of prevalences.

(2) There is the same prevalence levels between works with the same catchment areas i.e. Feilding (17.61%) and Longburn (16.88%) within the Palmerston North region.

Although Auckland has a much lower mean prevalence than Palmerston North or Hastings, it is my opinion that these could not be explained by inspection inaccuracy. The regional mean prevalences indicate that there might be true geographical differences in the prevalence of Sarcocystis infection.

No studies have been made on the geographical distribution of Sarcocystis infection in New Zealand. This author suggest that an investigation of some works from regions that showed different levels of prevalence be carried out to examine the regional differences established in this analysis.

Actinoform lesions

Actinoform lesions include those associated with actinobacillosis and actinomycosis. They are chronic focal suppurative inflammatory lesions usually with primary foci in the tongue (actinobacillosis), and maxilla and mandible (actinomycosis).

According to Powell (1979) predisposing factors to these diseases include those conditions that cause abrasions to the mucosa that occur in feeding low quality stalky materials as well as seed awns and coarse hay. He cited Hungerford (1970) as having reported that in New Zealand, actinobacillosis is seen after the burning of crops on peat country due to ingestion of gravel and ash causing abrasions of the mucosa.

In a study of 16 cases of actinomycosis in a beef herd, Bruere (1955), attributed the relatively high incidence of actinomycosis to the age susceptibility (3 - 4 years teeth erupting), together with the fact that steers grazed heavy swampy ground and frequently chewed barks and twigs of trees.

A significant regional difference of means was obtained in the analysis of prevalence of actinoform lesions. The levels of prevalences are higher in the three North Island regions than in the two South Island regions. Taking into account the work of Powell (1979), this may be attributed to different types of husbandry. Because of the

localisation of the lesions to the head, actinoform lesions are of minor direct consequence for the Meat Industry.

Obviously anyone can perform similar analyses of abattoir data providing vital statistics are available. All analysis were performed using a small pocket calculator with one memory. It was found that this task involved approximately one hours work for each disease condition. The results were later checked using the programmable calculator, an exercise which could be carried out in about five minutes for each condition. This, coupled with the fact that the minimum handling of data on a calculator lessens the probability of human error, suggests that a programmable calculator is a good choice for this kind of work.

CONCLUSION

"There is little point in performing elegant statistical manipulation upon heaps of figures if we do not know what the original data represented" (Blackmore and Harris, 1979). To be of any use vital statistics should be reasonably accurate or they should be at least precise (i.e. repeatable).

To assess the accuracy and/or precision of the vital statistics is obviously a difficult task but I believe the work described in the first part of this chapter indicates a high degree of accuracy of one of the conditions presently recorded. This would give some confidence to some of the data routinely generated by the Meat Division.

In the second part of this chapter an attempt was made to evaluate disease prevalences in different geographical locations of the country.

Some of the findings tend to confirm previous studies but it is also believed that in at least one of the conditions analysed (sarcocysts) some hitherto unseen geographical distribution of the disease was discovered. This indicates that close scrutiny and proper evaluation of available data may form a good basis for further investigation.

GENERAL DISCUSSION

Three techniques of handling data acquired from abattoirs were presented in this work. Firstly, a card index system was used to manually sort information from the "cancer eye" survey. Secondly, through a system of computer programs, two serological surveys were analysed. Thirdly, one-year vital statistics from meat works were evaluated by conventional methods, the so-called "pencil and paper" method in which statistical analyses were also performed with the aid of pocket calculators. Each of the techniques had inherent advantages and disadvantages.

The AZ64 printed card used in the manual sorting of data could contain 99 values represented by corresponding alphabetic letters and numbers cut along its edges. To analyse the data obtained from the "cancer eye" survey, 93 values from the measurements made of 784 cases of "cancer eye" were put onto AZ64 printed cards. A card index system is economical and could expedite the acquisition of information from survey returns. This technique requires no sophisticated equipment. It is a relatively inexpensive (6 cents per card) and effective method of obtaining information provided that the measurements could be accommodated on the index card. The card file should be limited to less than 1,000 units of analysis, or cases, and divided into subfiles of up to 100 cards each. Otherwise, sorting of information would be a very tedious process.

Through a system of package programs, two data files, each containing more than 1,200 cases and each of the cases with more than 70 established variables, were analysed in the computer. Its use is facilitated by the availability of a program that is applicable to the type of data for

statistical analysis. Setting up the basis of data rearrangements is necessary. Coding, key-punching and copying data, and other related tasks in entering information to the computer require careful proofing to check accuracy of data and information. Precise sets of instructions to the computer must be prepared to process the data correctly. However, such analysis requires the availability of expensive and large computer and all the related facilities such as input and output devices, key-punch machines and card readers. The type of analysis performed would have been almost impossible without the aid of a computer.

An evaluation was made of the conditions routinely recorded at the meat works. Data used in this evaluation are continually being generated from abattoirs. A greater use must be made of this type of data. It was simple to perform statistical analysis by "pencil and paper" combined with the use of a calculator. With further manipulation of data and the application of computer programs on the data base, similar results could be obtained. The only requisite for this type of analysis is the provision of reliable vital statistics and personnel with some knowledge of the relevant biometrics.

It is believed that all the techniques used in this contribution can also be applied in handling data that can be obtained from disease surveillance activities in the Philippines although the situation is different.

Animal disease surveillance in the Philippines is the task of the Regulations and Control Division of the Bureau of Animal Industry (B.A.I.). Under that division is the Disease Intelligence and Epidemiology Section which records and compiles disease situation reports submitted from field offices of the Bureau. Such reports contain the number of cases of

diseases encountered among farm animals in which government veterinary services are rendered.

To widen the scope of disease surveillance, organised poultry farms have been tapped as source of disease situation reports. Commercial poultry raisers employ practising veterinarians, either working as full-time farm managers or as visiting consultants, who are concerned with flock health, management and disease control activities and they could furnish the B.A.I. information on disease surveillance. This type of surveillance activity could be extended to pig farms and possibly other livestock industries.

Two specific activities should be given priority in confronting the task of disease surveillance :

(1) expressing disease situation reports as rates, and
(2) establishing other sources of data.

Rate is the expression of the frequency of disease occurrence in relation to a unit size of population. Instead of submitting reports as numbers of cases, these data should be calculated at the source as rates. It is imperative to establish the denominator population so that disease frequencies can be expressed as incidence and prevalence (Blackmore and Harris, 1979).

One source worthy of immediate consideration is the abattoir. This work showed the usefulness of abattoir data. In the Philippines, data could be obtained from similar establishments. Several operating policies established by two government agencies principally concerned with livestock,

the National Meat Inspection Commission (N.M.I.C.) and the B.A.I., could facilitate collection of data from the slaughterhouse :

(1) The N.M.I.C. trains veterinarians and meat inspectors for the execution of meat inspection procedures at the slaughterhouse.

(2) Seven slaughterhouses (Vitas, Pasay, San Juan, Mandaluyong, Philippine Integrated Meat Co., Food Terminal Inc. and Marulas) and a number of private meat plants in Metropolitan Manila operate under the supervision of the N.M.I.C. and during the period July - December, 1979, the Commission inspected and passed as fit for human consumption 40,886,481 kilograms and condemned 174,708 kilograms of meat and meat products (B.Carreon, pers.comm.).

(3) B.A.I. personnel supervise regular shipment of animals from the island provinces to Metropolitan Manila.

(4) Animals brought for slaughter are accompanied by shipping/transport permits issued from field offices of the B.A.I. Such permits specify the owner/shipper of animals and their points of origin.

Fascioliasis is one of the diseases for which a slaughterhouse survey could be carried out. This disease is known to be endemic in some regions of the country. For the past few years, the B.A.I. has instituted dosing of cattle and carabaos (water buffaloes) to control the disease in these regions. At present the efficiency of this control program is measured only by estimating the reduction of mortalities due to the disease. Its prevalence can be more objectively measured by the examination of livers of cattle and carabaos brought to the slaughterhouse from the liver fluke control areas.

Perusal of the guidelines employed in meat inspection procedures (Anon, 1977) shows that reports submitted record the volume of carcases and specific visceral organs that are condemned. Meat inspectors are supposed to indicate the causes of these condemnations. Of the possible causes of condemnations, 29 disease conditions have been listed and coded (Anon, 1977).

To be useful for disease surveillance a modification of the format of recording is necessary, and initially, it will probably be necessary to integrate the objectives of the two agencies, the B.A.I. and the N.M.I.C. The B.A.I. should make use of the recording system used by N.M.I.C. inspectors. An understanding must be reached to enable the recording of numbers of disease conditions found during meat inspection from which a data base can be established to determine the prevalence of disease conditions of animals brought to the slaughterhouse.

It is in these areas where the author hopes to apply the techniques learned from handling abattoir data. A card index system would be useful for a slaughterhouse survey of fascioliasis. The author most certainly hopes to improve the conventional method of data handling using "pencil and paper" and a calculator, on disease statistics from surveillance reports received by the Disease Intelligence and Epidemiology Section of the B.A.I. It is also hoped to establish disease prevalence data from some slaughterhouses in Metropolitan Manila by encouraging cooperation between the B.A.I. and the N.M.I.C.

It is hoped that the success of these initial projects will provide the stimulus for more extensive work in the future and the provision of computer facilities by the Ministry of Agriculture of the Philippines. This is not an unrealistic aim as such facilities are already available within the Ministry.

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LIST OF APPENDICES

"CANCER EYE" SURVEY

APPENDIX I : A SAMPLE RETURN OF "CANCER EYE" SURVEY

INDIVIDUAL CASE REPORT

Submitter's Case Ref. No.: 41 Works No.: 22

Date Examined: 28/5

Breed: Hereford Sex: M [ ] F [V] Castrate [ ]

Pigmented Eyelids: Yes [ ] No [V] Not Determined [ ] Age by teeth: 7/10

Locality or origin: Te Anau

Number in line: 1 Ref. Nos. of others in line affected: [ ]

Were all the animals in the line of the same breed? Yes [V] No [ ]

Eye affected: Left [ ] Right [V] Both [ ] (If both affected, complete two forms using same Ref. No. but with A and B prefix.)

Extent of Primary Lesion (complete a or b):

(a) Discrete single lesion [ ]

Size: <1 cm. [ ] 1-2 cm [ ] 2-5 cm [ ] >5 cm. [ ]

Site: Nictating membrane [ ] Upper lid [ ] Lower lid [ ] Sclera [ ]

(b) Evidence of local infiltration: [V]

Size: 1-5 cm. [ ] 5-10 cm. [V] 10-20 cm. [V] >20 cm. [ ]

Suspect primary site (if possible): Nictating membrane [V] Upper Lid [ ] Lower lid [ ] Sclera [ ]

Tissues involved: Nictating membrane [ ] Upper lid [ ] Lower lid [ ] Sclera [ ] Periorbital tissue [ ]

Evidence of gross secondary infection: Yes [ ] No [V]

Further comment on gross appearance: relatively small primary lesion with large metastasis in parotid L.N.

Gross evidence of metastasis in parotid L.N.: Yes [V] No [ ]

Gross evidence of metastasis elsewhere: Yes [ ] No [V]

Comment on site(s) and extent of metastases if present: distinguished macroscopical nodule in parotid L.N.

Diagnosis of primary confirmed histologically: Yes [✓] No [ ] Lab. Ref. No. [502/54]

Diagnosis of metastasis confirmed histologically: Yes [ ] No [ ] Lab. Ref. No. [ ]

Was the complete carcase condemned:

(a) at ante-mortem inspection? Yes [ ] No [✓]

(b) at post-mortem inspection? Yes [✓] No [ ]

Other comments: ......Specimen taken from Parotid Ln........

....

Signature: ....[illegible]....

Parotid Ln - S. Cell Carcinoma.

Appendix II

CARD INDEX SYSTEM CODE

Variable	Symbol	Description
BREED	A	Hereford
	B	Hereford cross
	C	Friesian and Friesian cross
	D	Other breeds
	E	Not indicated
SEX	F	Male
	G	Female
	H	Castrate
	I	Not indicated
PIGMENTED EYELIDS	J	Yes
	K	No
	L	Not determined
	M	Not indicated
	Mc	Pigmented right eyelid only
AGE	N	< 3 years old
	O	3 - 4 years old
	P	5 - 6 years old
	Q	7 - 8 years old
	R	9 -10 years old
	S	> 10 years old
	T	Full mouthed
	U	Adult
	V	Mature
	W	> 3 years old
	X	Aged
	Y	Old
	Z	Not indicated
EYE AFFECTED	A	Single eye, left
	E	Single eye, right
	I	Both eyes, left lesion described
	O	Both eyes, right lesion described
	U	Not indicated
NUMBER OF CASES IN THE LINE	1	One case
	2	Two cases
	3	Three cases
	4	Four cases
	5	Five cases
	6	Six cases

	7	seven cases
	8	eight cases
	9	not indicated
	10	more than eight cases
EXTENT OF PRIMARY LESION	11	single discrete lesion
	20	Two or more discrete lesions
	28	Local infiltration
	18	Ablated eye
SIZE OF DISCRETE LESION	12	< 1 cm
	13	1 - 2 cm
	14	2 - 5 cm
	15	> 5 cm
	16	not indicated
SITE OF DISCRETE LESION	21	Nictitating membrane
	22	Upper lid
	23	Lower lid
	24	Sclera
	25	Cornea
	26	Not indicated
SIZE OF LOCAL INFILTRATION	29	1 - 5 cm
	30	5 -10 cm
	31	10-20cm
	32	> 20 cm
	33	Not indicated
SUSPECTED PRIMARY SITE OF LOCAL INFILTRATION	34	Nictitating membrane
	35	Upper lid
	36	Lower lid
	37	Sc lera
	38	Cornea
	39	Not indicated
TISSUES INVOLVED IN LOCAL INFILTRATION	40	Nictitating Membrane
	41	Upper lid
	42	Lower lid
	43	Sclera
	44	Periorbital tissue
	45	Not indicated
GROSS SECONDARY INFECTION IN LOCAL INFILTRATION	47	Yes
	48	No
	49	Not indicated

METASTASIS OF PAROTID LYMPH NODE	50	Yes
	51	No
	52	Not indicated
METASTASIS ELSEWHERE	53	Yes
	54	No
	55	Not indicated
DISPOSITION OF PRIMARY LESION	56	Sent to laboratory
	57	Sent to laboratory and confirmed histologically
DISPOSITION OF METASTATIC LESION	58	Sent to laboratory
	59	Sent to laboratory and confirmed histologically
CONDEMNATION OF CARCASE	60	Condemned at ante-mortem
	61	Condemned at post-mortem
	62	Not condemned
	63	Condemned due to other causes.

APPENDIX III

CODEBOOK : SEROLOGICAL SURVEY OF MEAT INSPECTORS

Column	Variable Name	Variable description and code
1 - 2	WORKEMP	Works of Employment 1. Not classified 2. Borthwicks,Feilding 3. Longburn 4. Imlay, Wanganui 5. Wanganui Abattoir 6. Patea 7. Hawera,(Walkers) 8. Eltham,Huttons Meat Co. 9. Borthwicks, Waitara 10.Geat Meat, Petone 11.Wellington Abattoir 12.Borthwicks,Masterton 13.Horotiu,Hamilton 14.Gisborne 15.Gisborne Abattoir 16.Te Puke (Rangiuru) 17.Wairoa, Swifts 18.Tomoana,Hastings 19.Whakatu 20.Pacific Meats 21.Feilding Abattoir 22.Hellaby,Shortland 23.Westfield,Auckland 24.AFFCo,Southdown 25.Auckland Abattoir 26.Hellaby,Auckland 27.Whangarei Abattoir 28.AFFCo,Moerewa 29.Hellaby,Franklin 30.Picton 31.Blenheim Abattoir 32.Nelson 33.CFM,Belfast 34.CFM,Canterbury 35.Kaiapoi 36.N.Z.Ref.Co.,Islington 37.Christchurch Abattoir 38.CFM,Fairton 39,Burnside,Dunedin 40.Dunedin Abattoir 41.Mataura, Gore 42.Alliance Freezing Co. 43.Cambridge 44.Makarewa-Invercargill Works 45.Ocean Beach Freezing Co.Inv'll 46.Balclutha 47.Pukeuri,Oamaru 48.CFM,Pareora 49.Smithfield,Timaru 50.Hokitika Abattoir 51.Ashburton Abattoir
3 - 6	LABREF	Lab.Reference Numbers - Exact value
7 - 8	AGE	Age 15-65 99. Missing value
9	SEX	Sex 1. male 2. female 9. missing value
10	RACE	Race. 1. European 2. Maori 3. Islander 4. Others 9. Missing value
11	IMIGRANZ	Immigrant to New Zealand 1. No 2. From Europe 3. From Islands 4. From elsewhere 9. Missing value
12	DURIMIG	Duration of immigration to New Zealand 1 - 20 Exact value in years 21. > 20 yrs. 00 - non immigrant 99 - missing value
14-15	NYRINS	Number of years working as Inspector - Exact value
16	IGRADE	Present status as meat inspector 1. Assistant meat Inspector 2. Meat Inspector 3. Sr.Meat Inspector &Tutor 4. Supervising Meat Inspector 5. Veterinarian 6. Others
17	WOCONS	Contact with sheep at works 1. Presently in contact and up to 2 years ago 2. 2-5 years ago 3. 5 - 7 years ago 4. 7-10 years ago 5. >10 years ago 9. Missing value 0. No contact

18	WOCONC	Contact with cattle at works 1 - 5, 9,0 as above
19	WOCONL	Contact with calves at works 1 - 5,9,0 as above
20	WOCONP	Contact with pigs at works 1 - 5,9,0 as above
21	WOCONG	Contact with goats at works 1 - 5,9,0 as above
22-23	DUWOCONS	Duration of continuous contact with sheep at works. Exact value 99.Missing value
24-25	DUWOCONC	Duration of continuous contact with cattle at works. As above
26-27	DUWOCONL	Duration of continuous contact with calves at works. As above
28-29	DUWOCONP	Duration of continuous contact with pigs at works. As above
30-31	DUWOCONG	Duration of continuous contact with goats at works. As above
32	OUCONAGS	Previous contact with sheep outside works 1. with previous contact up to 2 years ago 2. 2-5 years ago 3. 5-7 years ago 4. 7-10 years ago 5. > 10 years ago 9. Missing value 0. No contact
33	OUCONAGD	Previous contact with dairy dattle outside works 1-5, 9,0 as above
34	OUCONAGB	Previous contact with beef cattle outside works 1-5,9,0 as above
35	OUCONAGP	Previous contact with pigs outside works 1-5,9,0 as above
36	OUCONAGG	Previous contact with goats outside works 1-5,9,0 as above
37	OUCONS	Present contact with sheep outside works. 1. Yes 2. No
38	OUCOND	Present contact with dairy cattle outside works. 1. Yes 2. No
39	OUCONB	Present contact with beef cattle outside works. 1. Yes 2. No
40	OUCONP	Present contact with pigs outside works. 1. Yes 2. No
41	OUCONG	Present contact with goats outside works. 1. Yes 2. No
42	OUCONDC	Contact with Dog and Cat 1. Yes 2. No
43	OUCONHP	Hunting possum 1. Yes 2. No
44	OUCONHD	Hunting deer 1. Yes 2. No
45	OUCONHPI	Hunting pig 1. Yes 2. No
46-47	SUFLEP	Previous Clinical Leptospirosis 1 - 15 No of years previous infected. Exact value 16 >15 years previously infected 77 Yes but No. of years not indicated 66 Yes but not medically confirmed 88 No 99 Missing value

48-49	SUFBRU	Previous clinical brucellosis. As above, 55 self injected
50-51	SUFTOX	Previous clinical toxoplasmosis. As above
52-53	SUFORF	Previous clinical orf. As above
54	LEPHAR	Hardjo test results 0. no test 1. negative 2. + 1:24 3. + 1:48 4. + 1:96 5. + 1:192 6. + 1:384 7. + 1:>384 9. Missing value
55	LEPPOM	Pomona test results, 1-7,9,0 as above
56	LEPCOP	Copenhageni test results, 1-7,9,0 as above
57	LEPTAR	Tarassovi test results, 1-7,9,0 as above
58	LEPBAL	Ballum test results, 1-7,9,0 as above
59	BRUSAT	Blanks
60	BRUCFT	Blanks
61	BRUAHG	Blanks
62	TOXTEST	Toxoplasmosis test results 0. not tested. 1. Negative. 2 Positive
63-64	MBLED	Month bled. 1-12 corresponding to month
65-66	YBLED	Year bled. 78,79 corresponding to year
67-68	MRBLED	Month rebled. 1-12 corresponding to month
69-70	YRBLED	Year rebled. 78-79, corresponding to year
71	RLEPHAR	Hardjo retest results. 1-7,9,0 as LEPHAR
72	RLEPPOM	Pomona retest results. 1-7,9,0 as LEPPOM
73	RLEPCOP	Copenhageni retest results. 1-7,9,0 as LEPCOP
74	RLEPTAR	Tarassovi retest results. 1-7,9,0 as LEPTAR
75	RLEPBAL	Ballum retest results. 1-7,9,0 as LEPBAL

APPENDIX IV

CODEBOOK : SEROLOGICAL SURVEY OF MEAT WORKERS

Column	Variable Name	Variable Description and Code
2	WORKEMP	Works of Employment : 1. Tomoana 2. Moerewa 3. Westfield 4. Hellaby,Auckland 5. Franklin 6. Southdown
3-6	LABREF	Laboratory reference numbers : Exact value
7-8	AGE	Age : exact value 99. Missing value (MV)
9	SEX	Sex : 1. Male 2. Female
10	RACE	Race : 1. European 2. Maori 3. Islander 4. European-Maori 5. Maori-Islander 6. European-Maori-Islander 7. Others 9. M.V.
11.	IMIGRANZ	Immigrant to New Zealand : 0. Not an immigrant 1. From Europe 2. From Islands 3. From elsewhere
12-13	DURIMIG	Duration of Immigration to New Zealand : 1-20 Exact value in years 21. > 20 years
14-16	NYRMEAT	Number of years as meat worker : Exact value, one decimal place
17-18	MWGRADE	Present status as meat worker : 1. Live animal worker (yardman, stockman, stock truck driver) 2. Slaughterboard worker (chain foreman, chain worker, beef butcher, mutton butcher, pig butcher, labourer,previously a meat inspector). 3. Chiller/Freezer/Chamber hand (worker and foreman) 4. Carcase Processor (boner,grader,trimmer, carton worker, cannery/cutting room worker, quality control worker) 5. Viscera Processor (small goods -, guthouse-, offal-, petfood worker and foreman, casing worker) 6. Shop butcher 7. Fellmongery and hide worker 8. Rendering department worker 9. Maintenance worker (fitter, plumber,electrician, carpenter, engineer) 10. Lab.staff and management 11. None or little animal contact (canteen worker, staff cleaner,driver, contractor, retired employees,storeman, out of job). 12. Unclassified worker 13. General worker (doing several jobs at a time) 99. Missing value
19	SLASHE	Sheep slaughterboard worker : 0. not a slaughterboard worker 1. slaughterboard worker not in contact with this species 2. slaughterboard worker in contact with this species.
20	SLACAT	Cattle slaughterboard worker. 0,1,2 as above
21	SLACAL	Calves slaughterboard worker. 0,1,2 as above
22	SLAPIG	Pig slaughterboard worker. 0,1,2 as above
23	SLAGOAT	Goat slaughterboard worker. 0,1,2 as above

24-26	JOBDUR	Duration at present job. Exact value, one decimal place 999 missing value
27-28	PMGRADE	Previous status as meat worker : 1-3 as MWGRADE 0. not applicable
29	PSLASHE	Previous sheep slaughterboard worker 0,1,2 as SLASHE
30	PSLACAT	Previous cattle slaughterboard worker. 0,1,2 as above
31	PSLACAL	Previous calves slaughterboard worker. 0,1,2 as above
32	PSLAPIG	Previous pig slaughterboard worker. 0,1,2 as above
33	PSLAGOAT	Previous goat slaughterboard worker. 0,1,2 as above
34-36	PJOBDUR	Duration of previous job; exact value,1 decimal place 999. missing value
37-38	SEPGRAD	Second previous status as meat worker 0,1-13 as PMGRADE
39	SESLSHE	Second previous job as sheep slaughter 0,1,2 as PSLASHE
40	SESLCAT	Second previous job as cattle slaughterboard worker 0,1,2 as above
41	SELSCAL	Second previous job as calves slaughterboard worker 0,1,2 as above
42	SESLPIG	Second previous job as pig slaughterboard worker 0,1,2 as above
43	SELSGOAT	Second previous job as goat slaughterboard worker 0,1,2 as above
44-46	SEPJOBDU	Duration of second previous status as meat worker Exact value, 1 decimal place 999. missing value
47	WOCONS	Contact with sheep at works 0. no contact 1. in contact
48	WOCONC	Contact with cattle at works 0,1 as above
49	WOCONL	Contact with calves at works. 0,1 as above
50	WOCONP	Contact with pigs at works. 0,1 as above
51	WOCONG	Contact with goats at works. 0,1 as above
52	SASSOC	Previous sheep-associated occupation 0. none 1. < 2 years ago 2. 2-5 years ago 3. 5-7 years ago 4. 8-10 years ago 5. >10 years ago 6. Yes, time interval not determined 9. missing value
53	CASSOC	Previous cattle-associated occupation. 0,1-6,9 as above
54	PASSOC	Previous pig-associated occupation. 0,1-6,9 as above
55	OUCONS	Present contact with sheep outside works 0. No 1. yes 9. missing value
56	OUCOND	Present contact with dairy cattle outside works 0,1,9 as above
57	OUCONB	Present contact with beef cattle outside works 0,1,9 as above
58	OUCONP	Present contact with pigs outside works 0,1,9 as above

59	OUCONG	Present contact with goats outside works 0,1,9 as above
60	DCCON	Contact with dog and cat. 0,1,9 as above
61	POCON	Contact with possum. 0,1,9 as above
62	DECON	Contact with deer. 0,1,9 as above
63	PICON	Contact with wild pig. 0,1,9 as above
64-65	SUFLEP	Previous clinical leptospirosis 0. no history 1-15 Exact value. number of years previously affected 16. >15 years previously affected 17. Yes, number of years not indicated 18. Yes,but not medically confirmed 99. missing value
66-67	SUFBRU	Previous clinical brucellosis 0,1-18,99 as above
68-69	SUFTOX	Previous clinical toxoplasmosis 0,1-18,99 as above
70-71	SUFORF	Previous clinical orf. 0,1-18,99 as above
72	LEPHAR	Hardjo test results 0. no test 1. negative 2. Seropositive 1:24 3. Seropositive 1:48 4. Seropositive 1:96 5. Seropositive 1:192 6. Seropositive 1:384 7. Seropositive >1:384
73	LEPPOM	Pomona test results. 0,1-7 as above
74	LEPCOP	Copenhageni test results. 0,1-7 as above
75	LEPTAR	Tarassovi test results. 0,1-7 as above
76	LEPBAL	Ballum test results, 0,1-7 as above
77	BRUSAT	Blanks
78	BRUCFT	Blanks
79	BRUAHG	Blanks
80	TOXTEST	Toxoplasmosis test results 0. no test. 1. negative 2. positive.

APPENDIX V

THE PUBLIC HEALTH SIGNIFICANCE OF LEPTOSPIROSIS FOR THE MEAT INDUSTRY

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INTRODUCTION

The genus leptospira consists of only two species. *L.interrogans*, the pathogenic species, is subdivided into more than 150 strains or serovars while *L.biflexa* consists of a variety of non pathogenic saprophytic serovars.

Although leptospires cannot be considered true psychrotophs, most serovars of *L.interrogans* have optimal growth *in vitro* at temperatures below 30°C and *L.biflexa* will grow at 13°C. Leptospires are also capable of surviving for periods of several weeks at chilling and freezing temperatures (Turner, 1974).

Although leptospires are not associated with meat spoilage, and only rarely with food transmitted diseases (Hergt, 1971), they can create an occupational hazard for certain groups of workers in the meat processing industry. Investigations in the U.K. (Schonell *et al*,1966), the U.S.A. (Bence and Miller, 1958, Braun, 1961), Australia (Forbes and Wannon,1964, and Hansman *et al*,1968) and New Zealand (Blackmore *et al*,1979) have demonstrated that leptospirosis is an occupational hazard of meat workers and meat inspectors. In most countries, leptospirosis is a relatively common disease of domestic stock and wild life and those serovars which are endemic in a country are usually adapted to specific maintenance hosts, which show minimal pathological responses to infection (Blackmore and Hathaway, 1979). Such maintenance hosts develop chronic renal tubular infection which persists for many months and even years. The infected kidneys and urine from infected animals are the usual source of infection for other animals including man. Transmission of infection from a maintenance host to a different species of animal often results in severe clinical disease.

The major risk for meat workers from leptospirosis is associated with the number of infected animals submitted for slaughter and the degree of direct contact with infected kidneys and urine. Contamination of the abattoir with leptospires capable of surviving in such an environment for some time may increase the risk.

On an international basis, it appears that endemic leptospirosis of sheep is uncommon; infection rates of cattle vary considerably and infection rates in pigs are high. The serovars endemic in a particular type of stock in one country may be quite different in another.

Only six serovars are known to be endemic in New Zealand, three of which are maintained in domestic stock. Cattle are the maintenance hosts for *hardjo* and pigs the maintenance hosts for *pomona* and *tarassovi*. Sporadic outbreaks of *pomona* infection can occur in cattle, usually as a result of contact with infected pigs (Blackmore, 1978). Surveys have shown that more than 60% of adult cattle have agglutinins to *hardjo* and that the majority of animals became infected between one and two years of age and remain leptospiruric for 9-20 months. It has been estimated that in many larger piggeries up to 80% of pigs between 3 and 12 months are infected with *pomona* and 10% with *tarassovi*.

Leptospirosis is a notifiable disease in New Zealand and the human incidence is high compared with many other countries, but the majority of such human notifications are of dairy farmers. It was therefore decided to initiate serological surveys of a variety of occupational groups in an attempt to more precisely define relative occupation risks of leptospirosis.

This paper records the results obtained from meat workers and meat inspectors. It also gives the results from a study of the survival of leptospires in kidneys held at chilling and refrigeration temperatures and discusses some of the public health implications of the results.

MATERIALS AND METHODS

Initial discussions were held with the Ministry of Agriculture, the Health Department, industry management and workers' unions to ensure maximum appreciation and cooperation. Each abattoir was sent a written explanation of the aims of the survey and a request for volunteers to give a blood sample for subsequent testing for antibodies against *Brucella abortus*, *Coxiella burnetti*, *Leptospira interrogans* and *Toxoplasma gondii*.

Abattoirs were visited and approximately 15ml of blood collected by venepuncture from each of 1,250 meat workers from six abattoirs and 1,003 meat inspectors from 44 abattoirs. Each worker was interviewed and a questionnaire completed. Information was recorded concerning the age, sex and race of the individual and a wide variety of other variables including exact type of occupation and time employed, present or previous contact with animals outside the abattoir and previous history of clinical leptospirosis or other zoonoses. More than 90% of the inspectors on duty at the time of the visits and the majority of workers at two of the abattoirs were bled. At the other four abattoirs most of the workers bled were those donating blood to the National Blood Transfusion Service.

Serum was removed from the blood after centrifugation and stored at -20°C until examined. A leptospiral microagglutination test (MAT) was carried out according to the method of Cole *et al*, (1973) with an initial final serum dilution of 1:24. Cultures of *ballum*, *copenhageni*, *hardjo*, *pomona* and *tarassovi* were used as representative of the serogroups endemic in New Zealand. Both *hardjo* and *balcanica*, which is also present in New Zealand, belong to the Hebdomadis serogroup and cross react.

Twenty pairs of pig kidneys, condemned because of lesions associated with leptospirosis were collected and each was divided into eight equal portions. Ten pairs of divided kidneys were stored at 0°C for 14 days and the others at -15°C for 30 days. At seven intervals during this period of storage a sample of kidney was removed and cultured in Johnson-Harris Bovine Serum Albumin Tween-80 semi solid medium. Leptospiral isolates were identified by a MAT. These methods have been described in detail elsewhere (Ho and Blackmore, 1979).

RESULTS

Tables 1 and 2 summarise the results recorded including the results obtained from 1,003 meat inspectors which have been recorded in greater detail elswhere (Blackmore *et al*, 1979). Preliminary analysis of the data obtained from an additional 211 meat inspectors from four more abattoirs revealed no significant differences in rates of serological prevalence and associations.

It will be noted that there is a significant difference in the overall prevalence rate of titres to leptospires of 6.3% in meat workers compared with the rate of 10.3% of inspectors ($P>0.001$).

Scrutiny of the prevalence rates of the overall titres to specific serovars (Table 1) shows that the rodent associated serovars *ballum* and *copenhageni*, are the lowest. Although *tarassovi*, a pig associated serovar, was lowest in meat workers, it was the second most prevalent in inspectors. The rate of *hardjo* titres was less than 1.5% in both occupational groups.

Pomona titres, which can be associated with pig contact, were the most prevalent in both occupational groups. Titres to both *pomona* and *tarassovi* accounted for 85% of leptospiral titres in inspectors and 49% of titres in meat workers. Of 376 inspectors working at abattoirs processing pigs, 52 (13.8%) had titres to these serovars compared with 36 (6.1%) at plants which did not slaughter pigs. This is a highly significant difference ($P>0.001$). A highly signficiant association also occurred between work exposure to the processing of pigs and the prevalence of *pomona* titres in meat workers ($P>0.01$). This association was particularly obvious at Works F (Table 1) which only processed pigs and where 23.1% of workers had titres to *pomona* although the plant had only been in operation for four years.

From the results of the questionnaires, a highly significant correlation ($P>0.002$) was shown between contact with pigs outside the abattoir and the probability of having a titre to *pomona*. This contact with pigs outside the abattoir could account for half the *pomona* titres of workers at Abattoir A (Table 1) which no longer slaughters pigs.

A total of 21 concurrent reactions to two serovars were detected. Of these, 18 were to *pomona* with one other serovar (seven with *hardjo*, seven with *tarassovi*, and four with *copenhageni*), two *copenhageni* with *ballum*, and one to *hardjo* with *ballum*. The concurrent reactions of *copenhageni* and *ballum*, *hardjo* and *pomona*, and *pomona* and *tarassovi* were significantly more ($P>0.001$) than would be expected by chance. This is indicative of dual infections and a common source of infection of those workers with dual titres, i.e. rodents, cattle and pigs respectively.

Table 1 demonstrates the prevalence of titres in different occupational groups. Although workers were subdivided into thirteen different occupational categories for the sake of clarity, these have been reduced to five in Table 2. It was interesting to note that more than 70% of workers in each category had not changed their type of job within the abattoir. All the titres of *hardjo* and *pomona*, which are serovars associated with domestic stock, occur in workers concerned with the slaughter and primary processing of stock. The other three serovars show no obvious association with specific occupation except for *tarassovi* in inspectors.

Twenty three (22%) inspectors who had titres to leptospires had a history of previous clinical leptospirosis confirmed by a medical practitioner. This compares with 12 (15%) of meat workers. Analysis of the data relating to the onset of previous clinical disease in meat inspectors showed that titres detectable down to a level of $\geq$1:24 can persist for at least 10 years (Blackmore *et al*, 1978).

Nineteen of the 20 kidneys yielded leptospires when cultured before chilling and freezing. All 19 isolates belonged to the *pomona* serogroup. One kidney was culturally negative before, and at all times during, the chilling experiment.

Seven of the nine kidneys (78%) stored at $0^{o}C$ were culturally positive after 14 days (Table 3) by which time there were signs of incipient spoilage. Eight of the 10 kidneys (80%) stored at $-15^{o}C$ were culturally positive after 30 days (Table 4) at which time the experiment was terminated.

Both chilling and freezing (from room temperature down to the respective temperature of 0°C and -15°C) occurred at an average rate of 1°C/h.

DISCUSSION

From a knowledge that rodents are the maintenance host of serovars *ballum* and *copenhageni* and the results from this survey, it would appear that neither are occupational hazards in the meat industry. Rodent infestation of an abattoir in New Zealand would be virtually impossible in view of the high standard of hygiene and building construction. If infection had been contracted from stock, it would be expected that the highest rates would be in workers concerned with the handling of carcases and fresh viscera as was the case with *hardjo* and *pomona*, but this was not the case for workers with titres to *ballum* and *copenhageni*. The dual reactions to *copenhageni* and *ballum* were significant and indicate a common source of infection, i.e. rodents. Therefore titres to these serovars should not be considered when assessing the true occupational risk of leptospirosis in the meat industry. By ignoring the *ballum* and *copenhageni* cases and correcting the concurrent titres, only 56 (4.5%) meat workers had evidence of occupational leptospirosis. Similar adjustment to the overall figure for meat inspectors would only reduce the figure to 10%.

There was a highly significant association ($P<0.001$) in both meat workers and inspectors between working with pigs and having a titre to *pomona*, but not between processing cattle and having a *hardjo* titre. This is surprising in view of the similar high prevalence rates of *hardjo* infections in cattle and *pomona* infections in pigs.

Both *pomona* and *hardjo* titres were only observed in workers processing fresh carcases and viscera and no titres were demonstrated in maintenance workers and engineers. This is in complete contrast to prevalence of titres to *Brucella abortus*, where maintenance workers are in the group most at risk (Blackmore *et al*, unpublished). This difference might suggest that maintenance workers contract brucellosis by aerosol and leptospirosis is less likely to be contracted by this method.

Although the overall figure for the occupationally associated prevalence of titres to leptospires has been estimated at 4.5% and 10% for meat workers and inspectors respectively, some of these seropositive cases will have been associated with contact outside the abattoir. A significant association between *pomona* titres and contact with pigs outside the abattoir has been demonstrated and there is evidence for a similar association between *hardjo* titres and contact with cattle.

Diesch (1971) demonstrated that *pomona* could survive in the manure of an oxidation ditch for 61 days. Work in the author's laboratory has shown that this serovar can survive in soil for 42 days under simulated New Zealand winter conditions (Hellstrom and Marshall, 1978). *Pomona* was also the only serovar which could be isolated from drainage water from a farm with stock infected with both *hardjo* and *pomona*. The explanation for this observation could be that *pomona* is a more persistant environmental contaminant than *hardjo*. However, dark field microscopy of urine from leptospiruric cattle and pigs, has shown that *pomona* infected pigs excrete much larger numbers of leptospires in their urine than do *hardjo* infected cattle (Mackintosh, pers.comm.) and therefore the total environmental contamination may be greater for *pomona* than for *hardjo*, thus favouring the isolation of the former.

In New Zealand a large number of adult dairy cattle, as well as younger beef animals, are submitted for slaughter. Only 2% of such culled cows have

infected kidneys. The majority of pigs submitted for slaughter are less than six months of age and if infected are still likely to be leptospiruric but the ratio of pigs to cattle slaughtered in New Zealand is about 1 to 3. It is suggested therefore that the greater occupational hazard constituted by *pomona* in pigs than by *hardjo* in cattle, could be associated with a greater resistance of *pomona* to environmental factors, a high concentration of organisms in pig urine and the high infection rates of pigs submitted for slaughter. The higher risk for inspectors compared with meat workers may be associated with the greater contact with kidneys during inspection procedures.

Sasse and Reuter (1978) demonstrated that *pomona* was able to survive at -40°C for ten days, when inoculated *post mortem* into pig kidneys. However, the results presented in this paper show that *pomona* is capable of surviving in naturally infected pig kidneys for at least 14 days at 0°C and more than 30 days at -15°C, a temperature frequently used for the storage of frozen meat products.

These findings reinforce the hypothesis that *pomona* is a relatively resistant organism. They also suggest that chilled or frozen products could remain a hazard for meat workers. In this respect, it is interesting to note (see Table 2) that 2.8% of those working in chillers and freezers had titres to both *hardjo* and *pomona*. People handling or preparing kidneys in retail butchers' shops or in the home may also be at risk. Contracting leptospirosis by such a method has been recorded in Germany by Hergt (1971).

Leptospirosis receives greater recognition in New Zealand as a common endemic disease of domestic stock and potential occupational hazard than in many other countries. However, surveys in Europe, North America and Australia, which have been referred to in the introduction of this paper, have shown similar or higher prevalences of titres to leptospiral agglutinins in meat workers, to those recorded here. The particular risk of pigs in relation to *pomona* infection in abattoir workers has also been noted in North America (Braun, 1961). It is therefore suggested that leptospirosis may be a much greater international occupational hazard of meat workers than hitherto suspected, especially in those countries with a large and intensive pig industry.

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Works	Number bled	Approx. % of total work force	Animals slaughtered	Specific Serovar Response											
				hardjo		*pomona*		*tarassovi*		*copenhageni*		*ballum*		Total	
				No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A	224		sheep, cattle	6	2.7	13	5.8	1	0.04	1	0.04	4	1.8	25	11.2
B	124		sheep, cattle	0	0	3	2.4	0	0	6	4.8	1	0.8	10	8.1
C	232		sheep, cattle	1	0.4	6	2.6	0	0	9	3.9	0	0	16	6.9
D	588	70	sheep, cattle pigs	9	1.5	9	1.5	1	0.2	2	0.3	1	0.2	22	3.7
E	56		sheep, cattle pigs	0	0	5	8.9	0	0	1	1.8	0	0	6	10.7
F	26	90	pigs only	1	3.8	6	23.1	0	0	2	7.6	1	3.8	10	38.5
Total 6	1250		-	17	1.4	42	3.4	2	0.2	21	1.7	7	0.6	89*	7.1
Meat Inspectors	1003	76	-	12	1.2	78	7.8	19	1.9	4	0.4	1	0.1	114+	11.4

* include 10 dual reactions, i.e. total seropositive individuals = 79 or 6.3%
\+ include 11 dual reactions, i.e. total seropositive individuals =103 or 10.3%.

TABLE 2 : ASSOCIATION OF SEROVAR REACTION WITH OCCUPATION

Type of Work	Number in Group	% with reaction to specific serovar					Overall % of serovar reaction
		hardjo	*pomona*	*tarassovi*	*copenhageni*	*ballum*	
With live animals in yard	60	nil	nil	nil	nil	1.7	1.7
Slaughter, evisceration and carcase dressing	364	2.7	6.6	0.5	1.9	0.8	12.6
Further processing of meat or offal	340	0.9	2.9	nil	1.8	0.9	6.5
In chillers & freezers	109	2.8	2.8	nil	nil	nil	5.5
Other type of employment within abattoir	323	nil	0.6	nil	1.9	nil	2.5
Meat inspection	1003	1.2	7.8	1.9	0.4	0.1	11.4

TABLE 3 : RECOVERY OF LEPTOSPIRES FROM PIG KIDNEYS CHILLED AT 0°C

Day storage	0	1	2	3	5	7	10	14
Kidney*								
C_1	+	+	+	C	+	+	+	+
C_2	C	+	+	+	+	+	+	+
C_4	-	+	-	-	-	-	-	-
C_5	C	+	-	-	-	-	-	-
C_6	+	-	+	+	+	+	+	+
C_7	+	-	+	+	+	+	+	+
C_8	+	+	+	+	+	+	+	+
C_9	+	+	+	+	+	+	+	+
C_{10}	+	+	+	-	+	+	+	+

C = contamination + = growth - = no growth

* Kidney C was apparently not infected and therefore has been omitted.

TABLE 4 : RECOVERY OF LEPTOSPIRES FROM PIG KIDNEYS FROZEN AT -15°C

Day storage	0	1	3	5	7	10	14	30
Kidney								
F_1	+	-	+	-	+	-	+	+
F_2	C	+	+	+	+	+	-	-
F_3	+	+	+	+	-	+	+	+
F_4	+	+	+	+	+	+	+	+
F_5	C	+	-	-	-	-	-	-
F_6	+	+	+	+	+	+	+	+
F_7	C	C	+	+	+	+	+	+
F_8	+	C	+	+	+	+	+	+
F_9	+	C	+	+	+	+	+	+
F_{10}	+	+	+	+	+	+	+	+

C = contamination + = growth - = no growth

HAZARDS FOR FOODBORNE INFECTIONS FOR MEAT WORKERS

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INTRODUCTION

Meat hygiene is the discipline concerned with the hygienic production of safe and wholesome meat products, and a prime objective is consumer protection. However, the hygienic measures instigated must also be designed to protect the health of the workers producing the products.

Occupational health is a complex discipline and, when related to workers in the livestock industry, must include consideration of occupation associated zoonoses. Some of the zoonoses of domestic stock which have been recorded as hazards for meat workers include anthrax, brucellosis, erysipeloid, leptospirosis and tuberculosis (Van der Hoeden, 1964). Two zoonoses which still appear to be major occupational hazards for meat workers in many countries are brucellosis and Q fever (Schnell *et al*, 1956, and Hansman *et al*, 1956). The risks from zoonoses will vary in different countries according to the prevalence of the diseases in domestic stock and standards of hygiene in the abattoir.

Of the 150 zoonoses recognised in the world only about 20 are endemic in New Zealand and less than ten affect domestic stock. However, approximately 35 million sheep and lambs, 2.4 million cattle, 1.2 million calves and 800,000 pigs are slaughtered each year and approximately 30,000 workers are exposed to these animals during their slaughter and processing. With the advent of the Accident Compensation Commission, which pays compensation to any New Zealand resident who suffers an accident or contracts certain occupational diseases, including brucellosis and leptospirosis, it became increasingly important to gain more information on the incidence of such diseases in different occupational groups.

It was with these facts in mind and the author's professional interest in veterinary public health that it was decided to instigate a serological survey of meat workers to gain more information on possible occupational associations with brucellosis, leptospirosis and toxoplasmosis. Although Q fever does not occur in New Zealand it was decided to test some sera for evidence of antibodies to *Coxiella burnetti*, to compare with results from other countries. It was also hoped to gain some less objective information on the incidence of other possible occupational zoonoses.

MATERIALS AND METHODS

Initial discussions were held with the Ministry of Agriculture, the Health Department, industry management and workers' unions in order to ensure maximum cooperation. Each abattoir was sent a written explanation of the aims of the survey and a request for volunteers to give a blood sample for subsequent testing for antibodies against *Brucella abortus*, *Coxiella burnetti*, *Leptospira interrogans* and *Toxoplasma gondii*.

Abattoirs were visited and approximately 15ml of blood collected by venepuncture from each of 1,250 meat workers from six abattoirs and 1,003 meat inspectors from 44 abattoirs. Each worker was interviewed and a questionnaire completed. Information was recorded concerning the age, sex and race of the individual and a wide variety of other variables including exact type of occupation and time employed, present or previous contact with

animals outside the abattoir and previous history of clinical leptospirosis or other zoonoses. This included showing each person a colour photograph of an orf lesion on a worker's hand. More than 90% of the inspectors on duty at the time of the visits and the majority of workers at two of the abattoirs were bled. At the other four abattoirs most of the workers bled were those donating blood to the National Blood Transfusion Service.

Serum was removed from the blood after centrifugation and stored at -20°C until examined. A leptospiral microagglutination test (MAT) was carried out according to the method of Cole *et al* (1973) with an initial final serum dilution of 1:24. Cultures of *ballum, copenhageni, hardjo, pomona* and *tarassovi* were used as representative of the serogroups endemic in New Zealand. Both *hardjo* and *balcanica*, which is also present in New Zealand, belong to the Hebdomadis serogroup and cross react.

Tests for Brucella and Toxoplasma antibodies were carried out by the National Health Institute. The Brucella tests were by a Standard Agglutination Test (SAT) (Alton *et al*, 1975) with initial serum dilutions of 1:20 and by subsequent testing by the Coombs test (Kerr *et al*, 1966). The Toxoplasma tests were by an indirect fluorescent antibody test (IFAT) (Sulzer and Hall, 1967) with an initial serum dilution of 1:16.

Tests for Coxiella antibodies were carried out at the Wallaceville Animal Research Centre, by a complement fixation test (CFT) as described by Lennett and Schmidt (1969) using a commercial antigen*.

RESULTS

Table 1 indicates the number of people who claimed to have suffered from a medically confirmed zoonosis, which could have been contracted as a result of their occupation. It was not possible to check on the validity of the statements. However, in respect of leptospirosis and brucellosis, there was a highly significant correlation ($P<0.001$) between a claim of previous clinical disease and having a titre to the appropriate antigen at the time of the survey.

TABLE 1 : REPORTED CASES OF CLINICAL DISEASE

Disease	Meat Workers		Meat Inspectors	
	No.	%	No.	%
Pseudocowpox *	5	0.4	1	0.1
Orf	15	1.2	40	4.0
Q fever	nil	-	nil	-
Erysipeloid	nil	-	nil	-
Leptospirosis	23	1.8	42	4.2
Brucellosis	39	3.1	34	2.8
Toxoplasmosis	nil	-	nil	-

* all cases contracted while working on dairy farms.

Only the sera from 112 meat workers and 243 inspectors from 24 abattoirs were examined by the CFT for evidence of Q fever, but all showed a negative reaction.

It must be appreciated that these figures in Table 1 give no indication of the annual incidence of the various diseases, and include data from workers who had only recently joined the industry as well as some who had been employed for more than 30 years. The questions were also biased in favour of gaining

* Behring Institute, Federal Republic of Germany.

information on leptospirosis, brucellosis and to a lesser extent orf. There was an indication of an increasing incidence of orf in meat workers in recent years. It was also interesting to note that all cases of the other pox virus zoonosis, pseudocowpox, had been contracted while working on dairy farms.

Sixty four percent of meat inspectors had titres of antibody to *T.gondii*, which is a very similar figure to that obtained from a control population of blood donors in 1976 of 61% (Metcalfe *et al*, 1973). No significant association could be found with either specific stock contact or cat ownership. Preliminary data from meat workers indicates very similar results.

The results related to leptospirosis have been published in detail elsewhere (Blackmore *et al*, 1979, Blackmore and Schollum, 1980). Inspectors are apparently at greater risk than meat workers with the overall serological rates being 10.3% and 6.3% respectively (see Table 2). However, some reactions were associated with the rodent adapted serovars; *ballum* and *copenhageni*, which were not considered to be indicative of occupational exposure. Thus the overall serological rates corrected for occupational exposure were 10% and 4.5%. Seropositive cases only occurred in those persons handling fresh carcases and viscera and the pig adapted serovars of *pomona* and *tarassovi* constituted much greater occupational hazards than *hardjo*, the cattle adapted serovar. Forty two (4.2%) of inspectors and 23 (1.8%) of workers claimed to have previously suffered from medically confirmed leptospirosis (see Table 1).

TABLE 2 : SUMMARY OF OVERALL PREVALENCE OF TITRES IN WORKERS AT DIFFERENT ABATTOIRS

Works	Number Bled	Animals slaughtered	Specific Serovar Response					
			hardjo %	*pomona* %	*tarassovi* %	*copenhageni* %	*ballum* %	Total %
A	224	sheep, cattle	2.7	5.8	0.04	0.04	1.8	11.2
B	124	sheep, cattle	0	2.4	0	4.8	0.8	8.1
C	232	sheep, cattle	0.4	2.6	0	3.9	0	6.9
D	588	sheep, cattle, pigs	1.5	1.5	0.2	0.3	0.2	3.7
E	56	sheep, cattle, pigs	0	8.9	0	1.8	0	10.7
F	26	pigs only	3.8	23.1	0	7.6	3.8	38.5
Total 6 Meat Inspectors	1250	-	1.4	3.4	0.2	1.7	0.6	7.1*
	1003	-	1.2	7.8	1.9	0.4	0.1	11.4+

* include 10 dual reactions, i.e.total seropositive individuals = 6.3%
\+ include 11 dual reactions, e.i.total seropositive individuals = 10.3%

Thirty four of 1,214 (2.8%) inspectors and 39 of 1,183 (3.1%)workers claimed to have previously suffered from medically confirmed brucellosis (see Table 1.).

Table 3 shows the overall distribution of different titres to *B.abortus* antigen in both meat workers and inspectors, and the percentage of individuals with a specific titre and a history of previous medically confirmed brucellosis. It is apparent that only a small proportion of inspectors with titre of 1:80 and below had clinical histories and it might therefore be concluded that the majority of such titres were non-specific. Although titres of ≥1:160 would be the most specific (i.e. ability to detect negative cases) they would lack sensitivity (i.e. ability to detect positive cases). It was therefore decided to take titres of 1:80 and above as the best overall estimate of previous infection. This titre also corresponds to that assumed to be associated with previous infection by some other workers (Wilson and Miles, 1967, and Coghlan and Longmore, 1973).

The serological prevalence of titres of 1:80 or greater of antibodies to *B.abortus* was 14.6% for meat inspectors compared with 4.8% for meat workers. However, it must be appreciated that the workers bled at three works were a very biased sample, because as a result of union activity, the majority had a vested interest in brucellosis. This bias is believed to be partially responsible for the higher percentage of workers,compared with inspectors, with a history of clinical brucellosis and titres of 1:40 or greater (see Table 3). Thus a smaller proportion of titres below 1:80 were non-specific than in the inspector group. The overall serological rate from these three abattoirs was 8.4% compared with 3.1% from the three other abattoirs where larger and more representative samples of the workers were bled.

TABLE 3 : OVERALL DISTRIBUTION OF TITRES TO *B. ABORTUS* AND CORRELATION WITH HISTORY OF UNDULANT FEVER.

Titre	Percentage of Population		Percentage with History of Disease	
	Inspectors	Workers	Inspectors	Workers
< 20	43.6	75.8	0.3	1.1
20	27.4	12.9	1.7	2.0
40	14.4	6.5	2.5	15.6
80	6.6	2.9	3.7	23.6
160	4.7	1.4	27.8	23.6
320	0.9	0.3	38.5	33.3
640	1.3	0.1	11.2	nil
1280	0.6	0.1	40.0	nil
2560	0.6	0.1	nil	nil
Total sera tested	868	1183	844	1181

With inspectors, who handle all classes of stock, it was difficult to correlate specific stock contact with positive titres and no associations were statistically significant. However, as might be expected there was a negative association with contact with sheep and a positive correlation with cattle. In addition there was a significantly higher ($P<0.05$) rate of titres in inspectors from the North Island (16%) compared with those from the South Island (11%).

As might be expected there was a significant association between workers with a titre to *B. abortus* and work with cattle (P<0.004). There was a similar association with pigs but cattle handlers are also the group who process pigs. A smaller proportion of workers handling sheep had positive titres compared with those handling other classes of livestock. Sera from meat workers from one abattoir were also subjected to a CFT using *Brucella ovis* as an antigen and positive results were only obtained from 11 workers, all of whom had concurrent titres to *B. abortus*. The highest percentage of seropositive cases were in those working in the rendering department and workers employed as maintenance engineers. Nineteen of 148 (12.8%)people in these groups had titres of 1:80 or greater and this was a significant occupational association (P<0.001). There was a trend towards an increasing prevalence of titres with the time a worker had been employed in the industry. For those employed for less than five years the rate was 2.9% compared with 6.4% for those employed for more than five years. Sera were also examined from 53 veterinarians working in abattoirs. Twenty (34.5%) had positive titres and 23 (39.5%) had a history of previous clinical brucellosis, but all believed that they had contracted the disease when in general practice and often as a result of accidents involving S19 vaccine. There were no significant associations between the prevalence of titres to leptospirosis and titres to *B.abortus* in any of the occupational groups.

DISCUSSION

Information on the incidence of occupation associated zoonoses in meat workers and inspectors was only obtained from interviews, and only in a few cases was the validity of a positive response confirmed by contacting the patient's physician. The data on medically confirmed occupational zoonoses (Table 1) can only be considered an indication of the relative risks. The relatively low occurrence of some of these diseases may indicate, a true low incidence, a low diagnostic rate or the failure of the worker to remember the illness or the diagnosis.

As pseudocowpox is most likely to be contracted from contact with infected cow's teats, it would be unlikely to be a common disease of meat workers. It is interesting to note that all six cases recorded were contracted by the individuals while they were working on dairy farms.

Fiftyfive persons reported orf infection of the hands. This is a common disease of New Zealand lambs and it is estimated that approximately 180,000 infected animals are slaughtered each year (A.J.Robinson, pers. comm.). Recent changes in sheep dressing procedures which evolve complete skinning of the head, may have increased the risk of contracting the disease. Claims to the Accident Compensation Commission, for contracting this disease from occupational contact, have increased from four in 1974 to 143 in 1979 (D.Clousto pers. comm.).

There was no evidence of exposure to Q fever in any of the people from whom sera were examined, and these results confirm once more that this disease is not endemic in New Zealand. It could be that occupational groups with a high exposure to animals constitute a useful sentinel group for detecting the presence of certain zoonoses, and in countries in which Q fever is endemic, a relatively high serological prevalence can be detected in meat workers (Hansman *et al*, 1966; Schonell *et al*, 1966).

It was interesting to note that no person was recorded as having suffered from erysipeloid. Although erysipelas is a relatively uncommon disease of pigs in New Zealand, *Erysipelothrix insidiosa* is a relatively common cause of arthritis in lambs (Kaferstein, *et al*, 1972).

Toxoplasmosis is apparently a widespread and common infection of sheep in New Zealand and a relatively common cause of ovine abortion. However, although the serological prevalence of titres to *T.gondii* was high in meat inspectors (64%), it was not significantly higher than expected from a normal population of New Zealanders. No significant correlations between seropositive persons and either stock contact or cat ownership were demonstrated.

Leptospirosis has been clearly shown to be an occupational hazard in the groups studied, and the results have been discussed in detail elsewhere (Blackmore *et al*, 1979 and Blackmore and Schollum, 1980). Two of the more important findings were the particular risk associated with the slaughter and processing of pigs and the greater risk to inspectors is associated with their greater contact with infected kidneys during inspection procedures. This study also demonstrates the importance of a knowledge of the epidemiology of each leptospiral serovar endemic in a country, when attempting to carry out such a study.

Compared with surveys from other countries (Buchanan *et al*, 1974, Hansman, *et al*, 1966 and Schonel *et al*, 1966) the prevalence of workers with titres to *B. abortus* was not high. This was not unexpected as the national bovine brucellosis eradication programme is progressing well. In January 1980 less than 1% of herds were infected, and the annual human incidence of undulant fever has decreased from 119 in 1974 to 45 in 1978 (Anon, 1979). The significantly lower percentage of inspectors with titre to *B. abortus* in the South Island is probably associated with a smaller number of dairy herds in this region of New Zealand. Even when bovine brucellosis was at a higher endemic level, the rate of infection in beef cattle was always less than in dairy breeds. It is interesting to note that the groups of meat workers most at risk to brucellosis were those working in the rendering departments which process condemned and inedible byproducts and those employed as maintenance engineers. It is suggested that a proportion of these cases could have been infected by the aerosol route. Buchanan *et al*, (1974) suggested a similar route of infection for maintenance workers in pig abattoirs in the U.S.A. Another factor which may be associated with the high risk for such workers, is the lower standards of hygiene in areas processing products considered inedible for humans. The apparent increased risk for inspectors could be associated with the incision of lymph nodes of infected cattle and the handling of uteri during routine inspection of viscera.

We have demonstrated that at least two diseases of stock (leptospirosis and brucellosis) constitute important occupational hazards for meat workers and inspectors in New Zealand. Although the risks are no greater, or even less, than those reported from other countries, they still constitute important public health problems. Other countries which have larger numbers or a greater prevalence of stock associated zoonoses, will have even greater problems. It is believed that this aspect of meat hygiene is often neglected and warrants greater international concern.

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