OPOSSUMS IN THE HOKITIKA RIVER CATCHMENT

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ABSTRACT

The condition, status and trend of populations of opossums (**Trichosurus vulpecula** Kerr) in the Hokitika River catchment and its tributaries were evaluated to assess the need for, and likely effect of, control campaigns.

Records of the history of infestation were examined. Fat reserves of males and females, growth rates, theoretical asymptotic weight of adult females, percentages of breeding animals, second breeding cycle, start of the breeding season and density were determined.

The opossums in the headwaters of Hokitika, Mungo and middle left of the Whitcombe catchment were in good condition; population density is high and is expected to increase further. Control operations in the Hokitika-Mungo headwaters are likely to be effective in reducing opossum numbers and protecting vegetation. In the headwaters and left bank of the Whitcombe, condition was very good and density very low, but expected to increase rapidly. In the rest of the area, animals were in fair condition, with moderate and generally declining densities.

INTRODUCTION

Because the plains traversed by the Hokitika and Kokatahi Rivers are 2-5 m below normal flood level they are particularly vulnerable to flooding and control of animals in the back country is considered to be a high priority (Holloway, 1959). Damage to the vegetation has been caused mainly by deer and opossums. The opossum is the most significant animal and will be much more difficult to control than deer because of larger numbers, a nocturnal way of life and a higher potential rate of increase. The higher rate of increase, and implied shorter generation length, suggests the possibility that successive generations may show increasing adaptability to poisons, as was found in wild rabbits (Rowley, 1963).

This paper describes the condition, status and trend of populations in the Hokitika and its tributaries. Opossums were liberated near Lake Kaniere (1902), in the Styx River (1910), near the Hokitika Gorge (Doughboy and Doctor Creeks, 1912) and near the Kokatahi gorge in 1922 (Pracy, 1962). Unrecorded private liberations were also made. From these foci, opossums dispersed over the entire catchment. Spread was accelerated by roads, bridges, tracks and the reduction of undergrowth by browsing ungulates. Now there are only some minor gaps in opossum distribution in the headwaters of the Hokitika and in the Whitcombe catchment.

Fig. 1 shows opossum densities for the Hokitika river catchment given by Pracy (unpubl. data) and Fokerd and O'Reilly (1966 unpubl.). The different poison operations are also indicated.

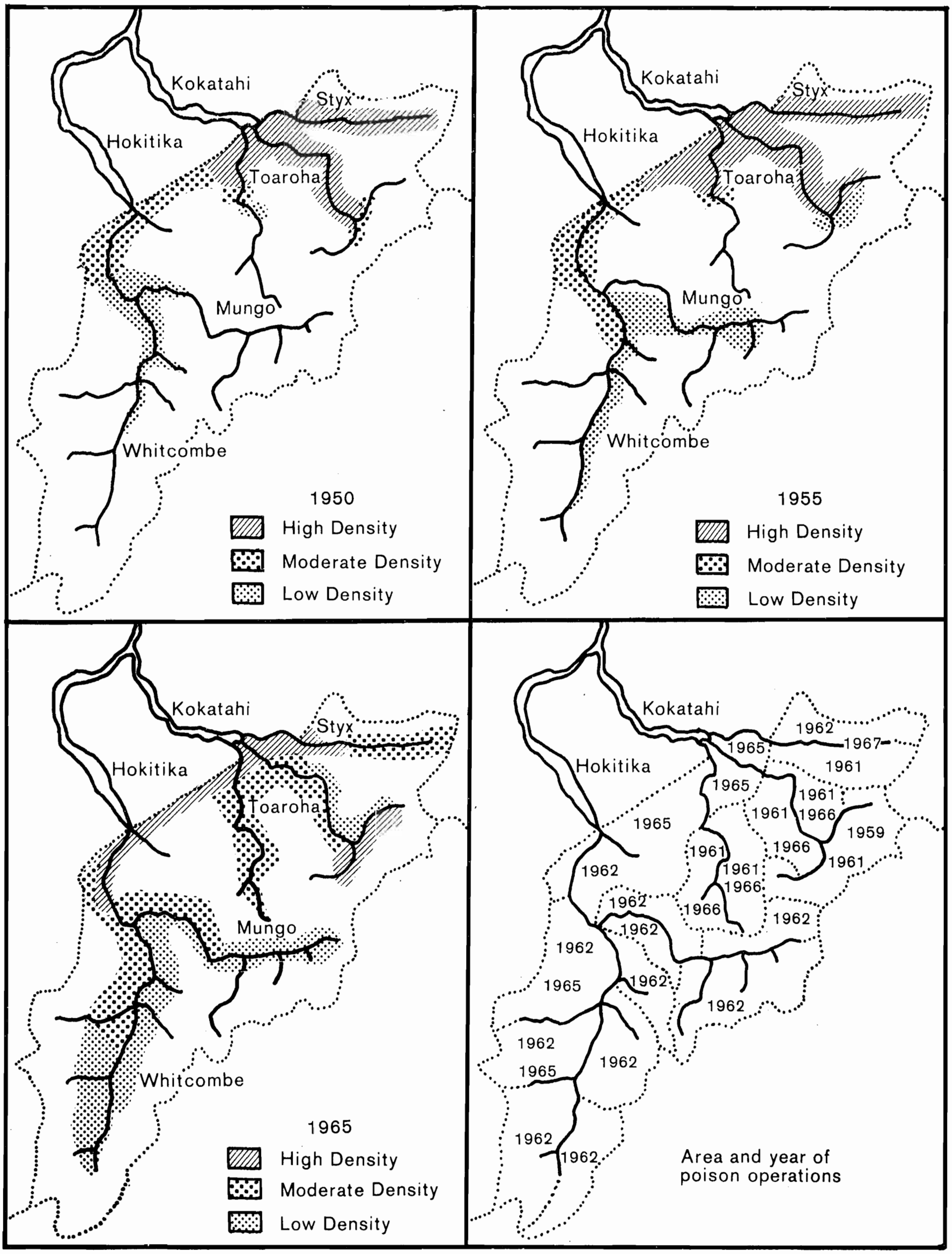

FIG. 1—Distribution and density of opossums in the Hokitika river catchment in 1950, 1955 (after L. T. Pracy) (pers. comm. unpublished Forest Service maps) and 1965 (Fokerd and O'Reilly, 1966). Area and year of aerial poisoning operations are included.

The number of animals caught per 100 traps over three nights in the headwaters of the Kokatahi (Fig. 2) suggest a slowly declining population between 1959 and 1967 (Cowlin and Barnett, unpubl. data).

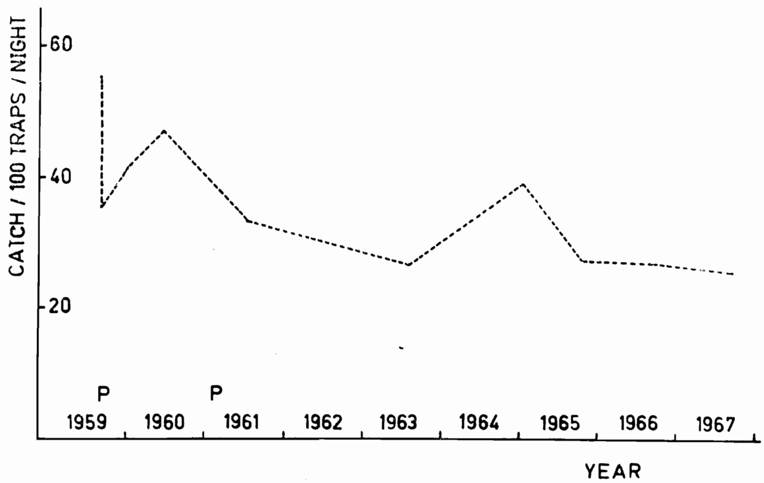

FIG. 2—Record of number of opossums caught per 100 trap nights (mostly from 3 nights' trapping) for 1959-1967, in the Kokatahi headwaters. Aerial poison operations (P) were carried out in 1959 and 1961.

MATERIAL AND METHODS

Demographic Characteristics

Opossums were sampled by killing with cyanide poison, traps and night-shooting between 30 September and 16 December 1971. Length, weight and fecundity data were taken. The age of females only was determined by counting annuli present in the cementum pad of the lower second molar, following the method described by Pekelharing (1970).

The growth of an animal depends on the amount and quality of the food ingested. When food is abundant, part of the intake is used in increased activity, part is used in acceleration of physical growth, and the balance is deposited in fat reserves. Thus size, growth rate and fat reserves are measures of condition which are appropriate to a survey of the present kind.

Bamford (1970) plotted weight against length of opossums and found a mean regression for both males and females of the form:

$$W = 0.0125\ l^{2.81} \quad (W = \text{weight, } l = \text{length}).$$

A standard weight can thus be calculated for a certain length, and the ratio between weight and standard weight can be plotted against the total fat reserves. The following equations gave the best fit:

$$f = -9.7 + 0.33\ (100W/W_s) \text{ for males, and}$$

$$f = -15.9 + 0.41\ (100W/W_s) \text{ for females.}$$

(f = fat reserves, W = weight, W_s = standard weight for measured length).

It was shown that fat reserves changed depending on the season of the year; however, they remained reasonably stable in the sampling period. Neither sex nor age had a significant effect on the fat reserves (Bamford, 1970).

Growth curves are generally described as logarithmic. In this study a modified form of Von Bertalaffny's growth curve (1934) was used:

$$W_t = W_{oo} - (W_{oo} - W_o)\,e^{-kt}, \text{ where}$$

W_t is observed weight at age t;
k is an exponential growth rate constant;
W_{oo}, the hypothetical weight at infinitely great age;
W_o, the hypothetical weight at age zero.

The exact age for animals over one year was calculated from an assumed mean birth date of 11 May (Bamford, 1972 unpubl.) and date of capture or, for animals less than one year, from head-length, tail-length and crown-rump length from a nomogram (Lyne and Verhagen, 1957).

The growth constant k, considered by Caughley (1967) to be most suitable for comparisons of growth in thar populations, seemed appropriate for this study. W_{oo} and W_o are fitted by iteration to minimise residual squares in the regression. Fixing W_o by iteration improved the fit. Because opossums grow very rapidly up to the age of about six months, it made a considerable difference if the 0-1 year-old animals were caught just before or just after that stage. For this reason, and because Bamford (1972 unpubl.) did not correct for exact age, the growth rates given in this paper cannot be compared directly with those given by Bamford.

Faecal Pellet Estimates of Relative Density

As discussed by Bamford (1972 unpubl.), counting of faecal pellets is the simplest and most reliable technique of estimating relative opossum densities at present. All data on the density of pellets on survey plots were obtained from C. J. Pekelharing (1973 unpubl.). Four thousand nine hundred and ninety-seven plots of 0.0004 ha were spaced at 20 m intervals followed on 65 restricted random lines which followed compass bearings uphill from valley floors. The presence of at least one intact pellet on each plot was recorded. The density index used here is the logarithmic transformation of frequency given by Fisher (1935):

$$d_i = \log_e \frac{100}{100 - p}$$

where p = the percentage of plots with pellets. Confidence limits were read from Table 15 a in Steel and Torrie (1966).

RESULTS

A. Number in Sample

A total of 2177 opossums were caught in the survey area and although an effort was made to sample uniformly, most were collected near tracks and huts. Table 1 shows the distribution of numbers in the sampling areas, the boundaries of which are shown in Fig. 3. Table 1 also gives the number of 0-1 year-old males, the age classes of females and the mean date of capture. Only females were aged because of the amount of work involved and because Bamford (1972 unpubl.) gave comparative data for females only.

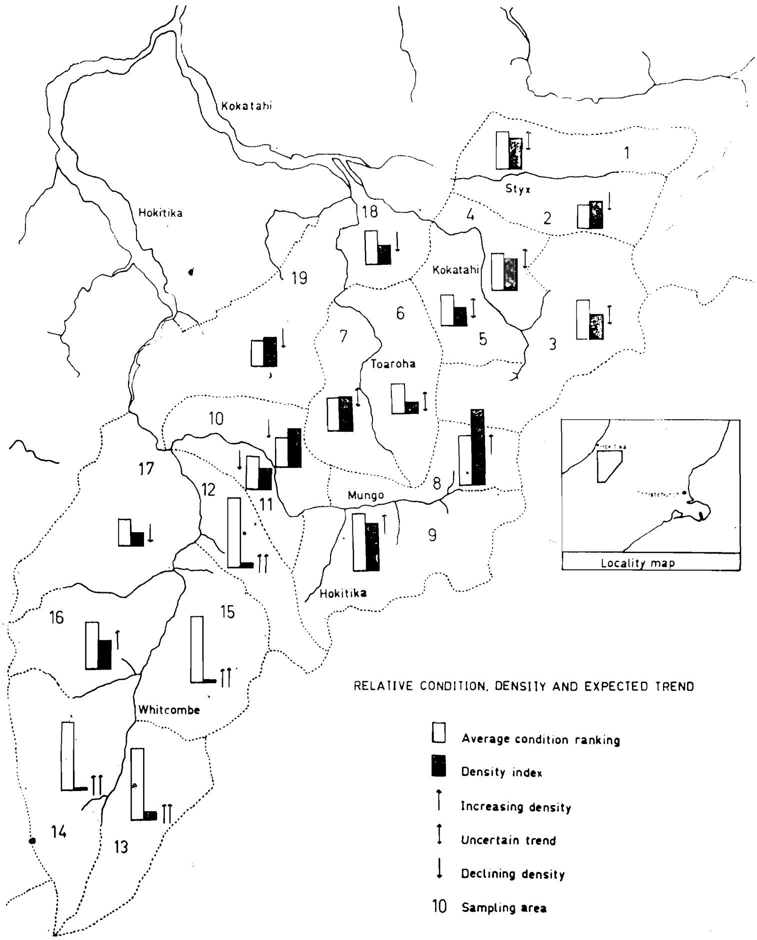

FIG. 3—Histogram presentation of relative ranking of opossums into 19 survey area units to portray their relative condition (light shading), density (dark shading) and inferred population trend (arrows). A double arrow indicates an expected rapid increase of numbers.

A significantly higher proportion of both adults (54.0%) and young males (57.1%) compared with females were caught during the survey. It is not known whether the predominance of males is related to an unequal sex ratio, or to differences in behaviour. However, Caughley and Kean (1964) also found a higher number of males (53.1%) in pouch young.

The age distribution of females showed a high mortality in the first year, a small mortality between the first and the fourth year and an increasing mortality after the fifth year. The oldest animal caught was 13 years old.

TABLE 1—The distribution of numbers and age in the sampling areas

	Mean day of capture	MALES Total	MALES 0-1	FEMALES Total	FEMALES AGE 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
1. Styx, true right	31 October	37	11	34	10	2	3	5	5	1	2	1	1	2	-	2	-	-
2. Styx, true left	30 October	115	25	75	22	9	9	8	7	9	3	3	1	3	1	-	-	-
3. Kokatahi, headwaters	4 October	75	17	77	22	15	6	7	10	9	3	2	-	-	2	1	-	-
4. Kokatahi, true right	16 October	59	13	43	11	10	9	5	2	3	1	1	1	-	-	-	-	-
5. Kokatahi, true left	8 October	58	18	60	14	11	7	7	9	5	3	2	1	1	-	-	-	-
6. Toaraha, true right	17 October	59	19	34	7	4	11	3	1	3	1	1	-	2	1	-	-	-
7. Toaroha, true left	18 October	49	16	33	6	4	7	8	-	4	2	1	-	-	-	1	-	-
8. Mungo, true right	15 November	27	7	29	4	2	6	3	-	1	5	4	2	-	1	1	-	-
9. Hokitika-Mungo, headwaters	17 November	40	15	41	6	3	8	5	8	2	3	3	-	1	-	-	1	1
10. Hokitika, true right	22 November	59	8	54	8	10	6	5	9	9	-	2	2	2	-	1	-	-
11. Hokitika, true left	11 November	54	17	58	6	12	3	7	9	4	10	4	2	1	-	-	-	-
12. Whitcombe, lower true right	6 December	73	23	62	17	6	6	12	9	5	4	2	1	-	-	-	-	-
13. Whitcombe, upper true right	7 December	85	26	65	21	1	14	7	6	10	1	-	1	2	1	-	-	-
14. Whitcombe, upper true left	5 December	43	12	44	12	5	6	8	6	1	-	2	3	1	-	-	-	-
15. Whitcombe, middle true right	15 December	56	24	53	17	8	5	6	6	5	4	-	-	1	1	-	-	-
16. Whitcombe, middle true left	14 December	100	24	76	18	10	7	4	15	8	7	3	-	1	2	1	-	-
17. Whitcombe, lower true left	3 December	53	13	57	11	13	7	8	4	5	5	1	3	1	-	-	-	-
18. Frontal country between Kokatahi and Toaraha	1 December	68	16	55	16	9	5	7	3	3	4	1	1	3	1	2	-	-
19. Frontal country between Toaraha and Hokitika	4 December	66	9	51	7	8	9	6	4	3	3	4	2	1	2	2	-	-
	TOTAL	1176	313	1001	235	142	134	121	113	90	61	37	21	22	12	11	1	1

B. *Fat Reserves*

Table 2 gives fat reserves for males and females. 0-1 year-old animals were excluded because they had considerably less fat than older ones, thus contributing to wider 95% confidence limits than calculated for the older animals.

TABLE 2—Fat reserves of males and females and average adult weight

	% Fat reserves, (males)	% Fat reserves (females)	Average weight(g) of females from 3 years & older
1. Styx, true right	23.3 ± 1.6	25.2 ± 1.9	3349 (±159)
2. Styx, true left	22.8 ± 0.8	22.8 ± 1.2	3095 (±149)
3. Kokatahi, headwaters	22.2 ± 1.0	25.4 ± 1.9	3544 (±180)
4. Kokatahi, true right	24.3 ± 1.1	27.0 ± 1.4	3473 (±202)
5. Kokatahi, true left	22.8 ± 1.3	25.2 ± 1.2	3502 (±124)
6. Toaroha, true right	24.7 ± 1.1	24.5 ± 1.7	3433 (±208)
7. Toaroha, true left	23.5 ± 1.4	23.5 ± 1.9	3406 (±190)
8. Mungo, true right	25.7 ± 1.5	28.0 ± 1.8	3800 (±100)
9. Hokitika-Mungo, headwaters	26.7 ± 1.2	29.7 ± 1.2	4002 (±123)
10. Hokitika, true right	24.8 ± 0.9	24.3 ± 1.0	3205 (±133)
11. Hokitika, true left	25.3 ± 1.4	25.0 ± 1.1	3189 (± 95)
12. Whitcombe, lower true right	29.1 ± 1.4	30.5 ± 1.5	3785 (±144)
13. Whitcombe, upper true right	29.1 ± 1.5	30.1 ± 1.3	3971 (± 98)
14. Whitcombe, upper true left	27.8 ± 1.6	29.3 ± 2.2	4048 (±203)
15. Whitcombe, middle true right	28.3 ± 1.5	29.7 ± 2.2	3957 (±200)
16. Whitcombe, middle true left	26.2 ± 1.2	25.7 ± 1.2	3611 (±113)
17. Whitcombe, lower true left	24.4 ± 1.2	24.2 ± 1.2	3072 (±147)
18. Frontal country between Kokatahi and Toaroha	24.4 ± 1.3	23.9 ± 1.6	3170 (±132)
19. Frontal country between Toaraha and Hokitika	24.1 ± 1.1	23.5 ± 1.2	3085 (±131)

The average weight of females 3 years old (by which time growth has virtually ceased) and of older females, is also given. Generally the heaviest animals had the highest fat reserves; in the headwaters of the Hokitika and Mungo Rivers, however, they were heavy but not very fat opossums. This exception suggests that in this area the quality of browse has deteriorated recently, probably because of the high density of the opossums.

C. Growth Curves

The asymptotes and the different constants for growth rates were calculated for the 19 different areas and are given in Table 3. Low values for the constants correspond with steep curves and therefore with a quick increase in weight (or high growth rate). There is a good correlation with the fat reserve data.

D. Fecundity, Date of First-born Young and Second Breeding Cycle

The percentages of females without young are given for the different areas and age groups (Table 4). The number of non-breeding one year-old females was significantly higher than that for non-breeding females of two years. Compared with these young animals, a significantly smaller proportion of females of three years and older was recorded as non-breeding.

The date estimated for first-born young for the different areas was taken as the average derived by nomogram of the five oldest animals sampled in the less than one year category. The dates show a considerable spread (Table 4). The opossums in the headwaters of the Hokitika and Mungo, where population density is high, appear to breed late; possibly an indication of declining amounts of suitable food. Another explanation could be that because of high population density the opossums need more time to establish and maintain their territories and consequently breed later.

The percentage of females breeding twice during the season studied is also given in Table 4. Opossums in areas with high fat reserves and high asymptotic weights were the only ones to breed twice. A factor of error, however, was the early date of capture for animals in the Styx, Kokatahi and Toaroha catchments, where most of the animals were caught before the expected second breeding cycle. All young born after 30 September were considered to be products of second breeding.

E. Condition, Density and Trend by Sub-catchments

The four measures of condition (fat reserves, asymptotic size, k and fecundity) were used to compile an approximate rank order of the 19 population units, from "best" to "poorest". As judged by each measure, the poorest population was given the rank position 1, and the best, 19. The average of all four measures was then calculated to give the overall rank order (Table 5 and Fig. 3). Although this technique tends to use the same data in different forms, and assumes that each measure of condition is of equal importance to survival of population, the deduced rank order is consistent with historical records and with condition of the vegetation (James, unpubl. report).

Styx, Kokatahi and Toaroha

The density, judged from pellet frequency, is now considered to be moderate. High densities were recorded during the 1950s and from trapping data (Fig. 2) so that it appears that density has since declined.

Barnett (pers. comm.) recorded average weights of opossums for the headwaters of the Kokatahi as 3180 g (1966), 3050 g (1967) (14 and 23 animals). The average weight in the present survey was 3120 ± 115 g. Average weight, fat reserves and asymp-

TABLE 3—Asymptotic size of females and constants for growth rate

	Asymptotic size of females (g)	Constants for growth rate
1. Styx, true right	3419 ± 160	0.92 ± 0.27
2. Styx, true left	3113 ± 263	1.06 ± 0.66
3. Kokatahi, headwaters	3607 ± 161	0.90 ± 0.16
4. Kokatahi, true right	3535 ± 209	1.00 ± 0.17
5. Kokatahi, true left	3563 ± 107	1.03 ± 0.13
6. Toaraha, true right	3446 ± 125	1.19 ± 0.36
7. Toaroha, true left	3496 ± 234	0.85 ± 0.26
8. Mungo, true right	3838 ± 107	0.85 ± 0.14
9. Hokitika-Mungo, headwaters	4106 ± 139	0.80 ± 0.16
10. Hokitika, true right	3262 ± 143	0.93 ± 0.19
11. Hokitika, true left	3204 ± 156	0.99 ± 0.18
12. Whitcombe, lower true right	3993 ± 277	0.68 ± 0.19
13. Whitcombe, upper true right	4140 ± 184	0.63 ± 0.11
14. Whitcombe, upper true left	4390 ± 413	0.55 ± 0.20
15. Whitcombe, middle true right	4422 ± 449	0.41 ± 0.14
16. Whitcombe, middle true left	3780 ± 540	0.62 ± 0.49
17. Whitcombe, lower true left	3144 ± 89	1.03 ± 0.20
18. Frontal country between Kokatahi and Toaroha	3191 ± 129	1.11 ± 0.33
19. Frontal country between Toaroha and Hokitika	3163 ± 263	0.76 ± 0.34
MEAN	3557 ± 159	0.92 ± 0.08

TABLE 4—Fecundity, date of first born young and second breeding season

	Percentages of non-breeding females 1 year	2 year	3 year	4 & older	All ages Total	Date of first born young	Percentage of females with second breeding season
1. Styx, true right	50	-	20	7	13	7 April	-
2. Styx, true left	33	-	-	4	8	11 "	-
3. Kokatahi, headwaters	53	-	-	1	16	4 "	-
4. Kokatahi, true right	30	-	20	-	13	14 "	-
5. Kokatahi, true left	73	-	-	-	17	9 "	-
6. Toaroha, true right	-	18	33	11	15	12 "	4
7. Toaroha, true left	25	14	-	-	7	25 "	-
8. Mungo, true right	50	-	-	-	4	24 "	-
9. Hokitika-Mungo headwaters	-	25	20	-	9	17 "	19
10. Hokitika, true right	80	33	40	16	35	9 "	-
11. Hokitika, true left	67	33	-	7	21	9 "	-
12. Whitcombe, lower true right	33	17	-	-	7	23 March	31
13. Whitcombe, upper true right	100	-	-	-	2	6 April	43
14. Whitcombe, upper true left	40	17	-	-	9	17 March	19
15. Whitcombe, middle true right	38	20	17	-	14	4 April	36
16. Whitcombe, middle true left	50	14	25	5	16	12 "	-
17. Whitcombe, lower true left	69	-	25	-	24	6 "	-
18. Frontal country between Kokatahi and Toaroha	33	20	-	6	13	2 "	3
19. Frontal country between Toaroha and Hokitika	100	44	17	10	34	11 "	-

TABLE 5—Density index of opossum pellets (derived from percentage of plots containing pellets)

	di	Confidence limits	Condition ranking
1. Styx, true right	0.24	0.18-0.30	8.6
2. Styx, true left	0.21	0.16-0.27	5.3
3. Kokatahi, headwaters	0.19	0.14-1.25	9.0
4. Kokatahi, true right	0.24	0.16-0.32	8.3
5. Kokatahi, true left	0.14	0.09-0.19	7.3
6. Toaroha, true right	0.09	0.06-0.14	6.9
7. Toaroha, true left	0.26	0.18-0.39	7.6
8. Mungo, true right	0.58	0.39-0.80	11.3
9. Hokitika-Mungo, headwaters	0.36	0.26-0.48	13.1
10. Hokitika, true right	0.30	0.24-0.36	7.0
11. Hokitika, true left	0.16	0.10-0.26	7.6
12. Whitcombe, lower true right	0.04	0.02-0.09	16.1
13. Whitcombe, upper true right	0.06	0.03-0.15	16.4
14. Whitcombe, upper true left	0.02	0.01-0.03	15.7
15. Whitcombe, middle true right	0.02	0.00-0.09	15.4
16. Whitcombe, middle true left	0.22	0.18-0.27	10.7
17. Whitcombe, lower true left	0.10	0.08-0.14	6.3
17. Whitcombe, lower true left	0.10	0.08-0.14	6.3
18. Frontal country between Styx and Toaroha	0.14	0.08-0.20	7.9
19. Frontal country between Toaroha and Hokitika	0.22	0.19-0.28	6.0

totic weights (Table 2) were about the same or lower than those given by Bamford (1972 unpubl.) for a stable population, suggesting that density was still slowly decreasing. It is, however, uncertain whether the number of opossums will stabilise or build up to another population peak.

Lower Hokitika, lower left of the Whitcombe and frontal country

This situation was similar to the Styx, Kokatahi and Toaroha. Fat reserves and asymptotic weights were smaller than those for Bamford's stable population. The density in the lower Hokitika was still fairly high, and here a natural reduction can be expected. Distribution of animals in the frontal country was irregular, at least partly because of frequent human interference.

Headwaters of Hokitika-Mungo and middle left of the Whitcombe

High densities, high fat reserves, large theoretical asymptotic weights and high fecundity values all indicated that the animals were in good condition and likely to be increasing in numbers. However, recent defoliation of rata (*Metrosideros umbellata*) and kamahi (*Weinmannia racemosa*) (James, unpubl. report) suggested that browse in the headwaters of Hokitika and Mungo was decreasing in suitability. It can be expected that a population peak will be reached in a few years' time, followed by a natural reduction.

At this stage vegetation is most vulnerable, and it might be advantageous to reduce animals rapidly by poisoning. A kill of 40%-50% could be expected (Bamford and Martin, 1971), which could save irreparable damage to many trees.

In the middle left of the Whitcombe density was not high, and condition not very good, so that the population peak will occur later than in the headwaters of the Hokitika-Mungo.

Whitcombe headwaters

In all measured aspects, condition of the opossums in these areas was very good. Fat reserves and theoretical asymptotic weights were higher than those of Bamford's increasing population. The average weights were also high, the heaviest animal being 5800 g. A high proportion of the females were breeding twice (33%), and only a small percentage were not breeding at all (8%). Growth rates were much higher than those for the other areas.

The very low density and records of the past show only a short history of infestation, so that an increase of more than 17% per year can be expected (Bamford, 1972 unpubl.). The effect of a poisoning operation, with a kill of about 30%, would probably be nullified in one year and is not considered to be useful.

DISCUSSION

Significant differences were found in fat reserves, theoretical asymptotic weights, growth rates and females with a second breeding cycle between different areas. Ranking of the different aspects of condition also corresponded.

Past poisoning operations have failed to change the extent of opossum infestation in the surveyed area. The evidence for this is provided by the historical data, the results of repeated sampling with traps in the Kokatahi and Styx catchments, and the absence of any apparent influence of poisoning operations on the age structure and other population parameters measured in the present survey.

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REFERENCES

BAMFORD, J. M. (1968): Assessing the effectiveness of an aerial poison campaign against opossums in Westland. **New Zealand Forest Research Institute, Protection Forestry Report No. 46** (Unpublished).

——— (1970): Estimating fat reserves in the brush-tailed possum, **Trichosurus vulpecula** Kerr. (Marsupialia: Phalangeridae). **Australian Journal of Zoology 18:** 415-25.

——— (1972): The dynamics of possum (**Trichosurus vulpecula** Kerr) populations controlled by aerial poisoning. Ph.D. Thesis, University of Canterbury (Unpublished).

BAMFORD, J. M. and MARTIN, J. (1971): A method for predicting success of aerial poison campaigns against opossums. **New Zealand Journal of Science 14:** 313-21.

BERTALANFFY, L. VON (1934): A quantitative theory of organic growth inquiries on growth laws: II. **Human Biology 10 (2):** 181-213.

CAUGHLEY, G. (1967): Parameters for seasonally breeding populations. **Ecology 48:** 834-9.

CAUGHLEY, G. and KEAN, R. I. (1964): Sex ratios in marsupial pouch young. **Nature, 204,** No. 4957: 491.

FISHER, R. A. (1935): The design of experiments. Hafner Publ. Co. New York. 8th ed. 248pp.

FOKERD, S. E. and O'REILLY, M. F. (1966): Preliminary report and plan for control of noxious animals in the Hokitika river catchment. **New Zealand Forest Service Report** (Unpublished).

HOLLOWAY, J. T. (1959): Noxious animal problems of the South Island alpine watersheds. **New Zealand Science Review, 17:** 21-8.

LYNE, A. G. and VERHAGEN, A. M. W. (1957): Growth of the marsupial **Trichosurus vulpecula** and a comparison with some higher mammals. **Growth 21:** 167-95.

PEKELHARING, C. J. (1970): Cementum deposition as an age indicator in the brush-tailed possum **Trichosurus vulpecula** Kerr (Marsupialia) in New Zealand. **Australian Journal of Zoology 18:** 71-6.

——— (1973): Status of introduced mammals in the Hokitika catchment, Westland. **New Zealand Forest Research Institute, Protection Forestry Report 122** (Unpublished).

PRACY, L. T. (1962): Introduction and liberation of the opossum, **Trichosurus vulpecula** Kerr, into New Zealand. **New Zealand Forest Service Information Series 45:** 28pp.

ROWLEY, I. (1963): Field enclosure experiments on the technique of poisoning the rabbit, **Oryctolagus cuniculus** (L.). **CSIRO Wildlife Research 8:** 143-53.

STEEL, R. D. G. and TORRIE, J. H. (1960): "Principles and procedures of statistics." McGraw-Hill, New York. 458-9.