DETERMINATION OF THE PLANE OF NUTRITION OF CHAMOIS

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SUMMARY: Autopsy data was collected from three chamois (*Rupicapra rupicapra*) populations to investigate the use of various measurements for determining mean planes of nutrition. Significant differences in measurements of horn length for each age class between populations were found, indicating that horn length analysis could be used to give some index of population condition. Total body length was significantly different for the youngest age classes of each population. These differences become negligible around three years of age. Analysis of the Arawata population by weight indices showed only slight differences between inter-population areas. Similarly, fecundity rates failed to produce significantly different values for the three populations.

INTRODUCTION

The catchments from the Okuru River to the Arawata River, South Westland, were surveyed by the Protection Forestry Division, Forest Research Institute, in the summer of 1970/71. The sample of chamois obtained from this area, (henceforth called the "Arawata" sample), was collected with the co-operation of Luggate Game Packers, (a commercial game recovery firm), from November 1970 to February 1971, with two further samples taken in March and in May/June, 1971.

For comparison with the survey sample, data have been used from chamois populations in the Clyde tributary of the Rangitata River, Mid Canterbury, and in the Copland River, Westland National Park. Both these samples were foot-shot in the summer of 1965/66 (Caughley, 1970).

This paper examines the value of measures of physical condition for comparing differences in mean planes of nutrition between chamois populations. Plane of nutrition as used in this paper, can be defined as the quantity and quality of per capita food intake.

In a comparison of the three chamois populations, planes of nutrition can be affected by a number of factors e.g. length of occupation by chamois, climate and vegetation, and past grazing by other large concentrations of ungulates. The Copland and Rangitata areas were both colonized in the 1915-1920 period, while the Arawata has had a far shorter period of occupation by chamois (approximately since 1950, see Fig. 1). Climatic and vegetative conditions vary considerably between the Copland and Rangitata areas (Anderson and Henderson, 1961, Caughley, 1970), as west of the Main Divide food is generally more abundant, faster growing, and the climate milder but with a higher rainfall. Climatic and vegetative conditions in the Arawata are more similar to the Copland, than to the Rangitata. In the Rangitata, past grazing by large numbers of deer, sheep and, since 1954, thar (Caughley, 1970), have reduced available food. Red deer entered the Arawata prior to chamois, and reached high densities in the late 1950's (Challies, pers. comm.). It is suspected that in a comparison of the Copland and Arawata areas, the length of occupation by chamois is of greater importance in determining the general level of nutrition, than the effect of high concentrations of red deer in the same area. It is logical to conclude that there exists an upward gradation in mean plane of nutrition for the three chamois population, in the order: Rangitata: Copland: Arawata.

It has been assumed throughout this paper that the plane of nutrition of a population directly affects the size of the individuals within that population. The effects of differing nutritional planes upon individuals of various ungulate species have been recorded by various workers e.g. Fowler, 1968; Widdowson, 1968. The energy balance that exists between a particular environment and the herbivore population that it supports can be evaluated in a number of ways, particularly by using the rate of growth of feral individuals that comprise that population (Wood and Cowan, 1968). Wood and Cowan

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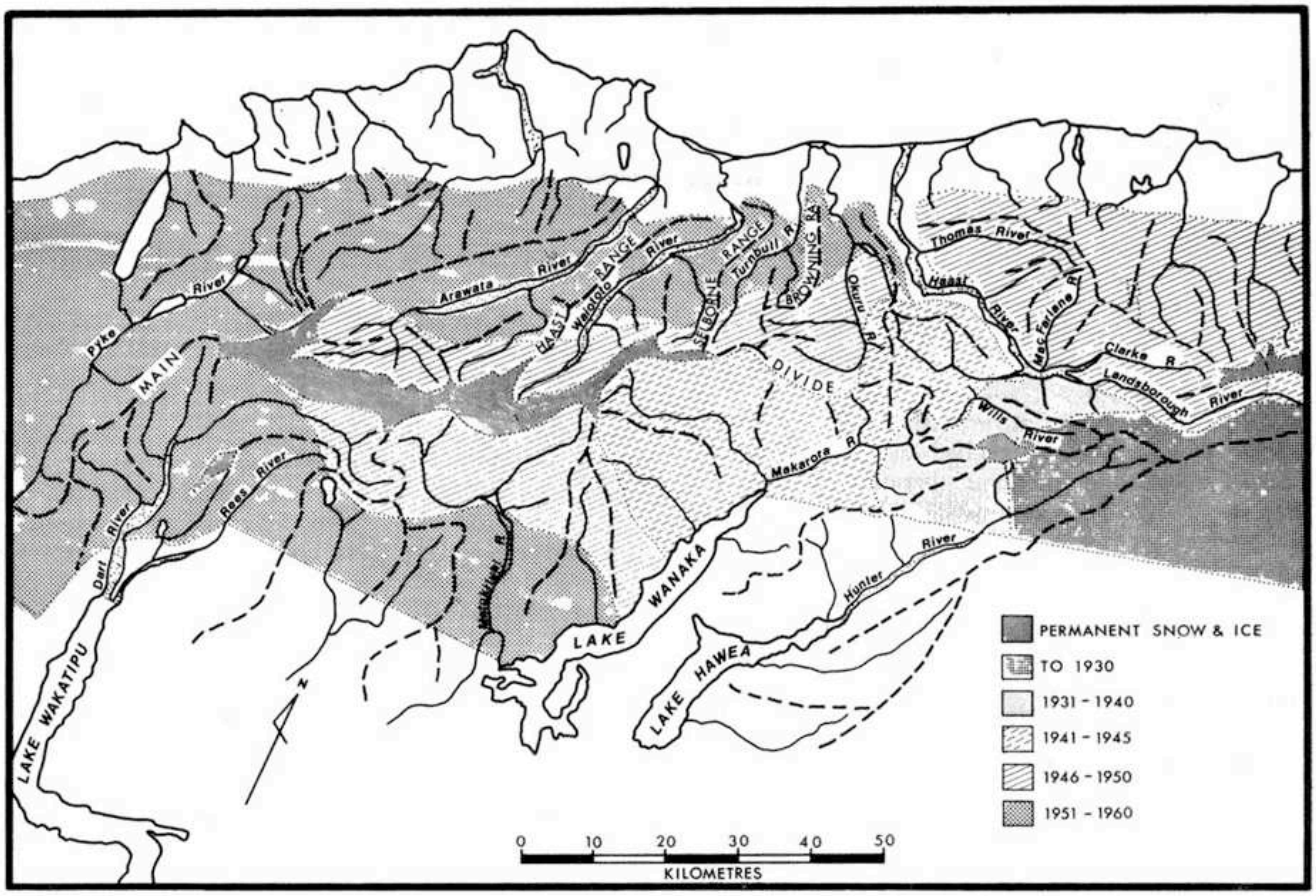

FIGURE 1. *Dispersal of chamois into South Westland and West Otago.*

also state that by using various planes of nutrition, (defined by them as planes of energy intake), it is possible to rear individuals at growth rates ranging from zero to the upper genetic limit of the species. Bandy, Cowan and Wood (1956), consider that for deer (species unspecified) less than two years of age, it is possible, from a knowledge of various growth parameters (hind foot length and heart girth in this example), to make a reasonable evaluation of the range conditions on which the measured individuals were reared.

The data taken during autopsy in this study enabled a comparison of animal body size between the three populations. Analysis of the age structure of the Arawata population was not attempted because helicopter operations tend to pursue only the larger groups of animals which consist mainly of females, yearlings, and kids (A. Hawker, pers. comm.). At the time of sampling adult males were mostly in smaller groups separated from females and juveniles.

HISTORICAL

In 1907, eight Austrian chamois were liberated in the Hooker Valley, Mt Cook National Park with a further liberation of 2 animals in 1914. Government hunting operations specifically for chamois and thar began in the Mt Cook/Rangitata area in 1937 and continued for some 5 years. Further deer and chamois operations in the Rangitata continued for many years. By the mid 1930's chamois were still north of Haast Pass (Yerex, 1934) but by the following decade they were seen and shot south of the main Haast River, (see Fig. 1). Chamois appear to have moved down the eastern side of the Main Divide and progressively colonized the western catchments from this direction. In the summer of 1948-49 F. Stratford reported chamois, in relatively small numbers, in most of the valleys south of the

Haast, except the Arawata. By 1950 the heads of all the valleys in the survey area were colonized but populations were low, with the exception of the Waitoto.

Within the survey area, past shooting has been both sporadic and light. Between 1940 and 1957 the Okuru and Turnbull rivers and the Marks Range were shot by Internal Affairs employees, while the heads of the more southern valleys were subject to light hunting. The prime object of these operations was to reduce deer numbers, with chamois of secondary importance. In 1955-56, some 280 chamois were shot in the Haast Zone (Landsborough through to Turnbull, inclusive).

With the cessation of government hunting, chamois hunting in the area was negligible until commercial venison recovery firms began operations in 1964/65. With the decline in deer numbers, chamois are being shot more intensively and this trend is likely to continue.

Severe outbreaks of kerato-conjunctivitis have affected both the Rangitata and Copland populations. The Rangitata population mortality was estimated to be 50% for 1947-48 (Daniel and Christie, 1963), while the Copland mortality was 62-70% in 1960, (Cummings, 1960), and a further 50% the following year (Daniel and Christie 1963).

MATERIAL

Autopsy data collected from the foot-shot Rangitata and Copland animals included sex, total body length and reproductive status. Also the right horn and paw bone were removed for ageing (Caughley, 1970). Carcass weights were not recorded.

For the Arawata animals, the requirements and methods of helicopter-based game recovery operations precluded the removal of jaw bones for ageing and jaw length measurements, and the recording of reproductive status of females. For adult animals (with a full complement of permanent incisors), the first incisor was removed for ageing in the laboratory, using cementum annuli (Pekelharing, 1969). Individuals under three years old were assigned age classes in the field using the eruption sequence of the permanent incisors (Couturier, 1938). Area where shot, sex, total body length, horn length, some carcass weights, and in later months, the occurrence or otherwise of lactation were also noted.

As mentioned in the introduction, the social organisation of the population at the time of sampling has resulted in sexually biased samples (see Table 1), which has unfortunately confined data analysis to that of females.

When all genitalia were removed during field evisceration, sex was determined in young males by examining the remaining penis base at the pelvic symphysis. Eviscerated adult animals could be sexed by horn form and urine staining on the abdomen of males.

TABLE 1. *Arawata: number of autopsied individuals by sex and month.**

	December	January	March	May/June	Totals
Male	20	17	7	0	44
Female	32	21	19	70	142
Total					186

* Samples from May and June lumped.

Assuming a mean kidding date of 24th November, (Caughley, 1971) all animals were assigned to annual age classes designated by the number of completed years of life. Total body length was measured in whole centimetres, from the anterior tip of the nose, along the curve of the spine to the posterior tail-bone segment (this approximates the length of the vertebral column including the head). Horn length, to the nearest millimetre, was measured over the outer curve of the right horn. Carcass weight in pounds, taken where possible, was the weight of the animal including head and skin, but minus the viscera. In the later samples from the Arawata, adult females without milk were assumed to have lost a kid previous to shooting, or to have not bred in the 1970-71 season, (see Table 6).

RESULTS

Horn Length

Horn length data is summarised in Appendix I. Five age classes and three populations were tested by analysis of variance as possible sources of variation in female horn measurements (Table 2), (ages 3, 4, 5, 6 and 7).

TABLE 2. *Analysis of variance of horn length of all adult females.*

Source of variation	F ratio	Significance level	D.F.
Population	20.20	*	12
Age class	5.39	*	10

(* Significant at the 0.01 level.)

Variation in horn length, at least for females, is sufficient to give a significant separation of the data by both population and age class. This result should be accepted with some caution for the older age classes as sample sizes are small. Measurements of female horn length for each age were tested for a significant regression of horn length with age. This

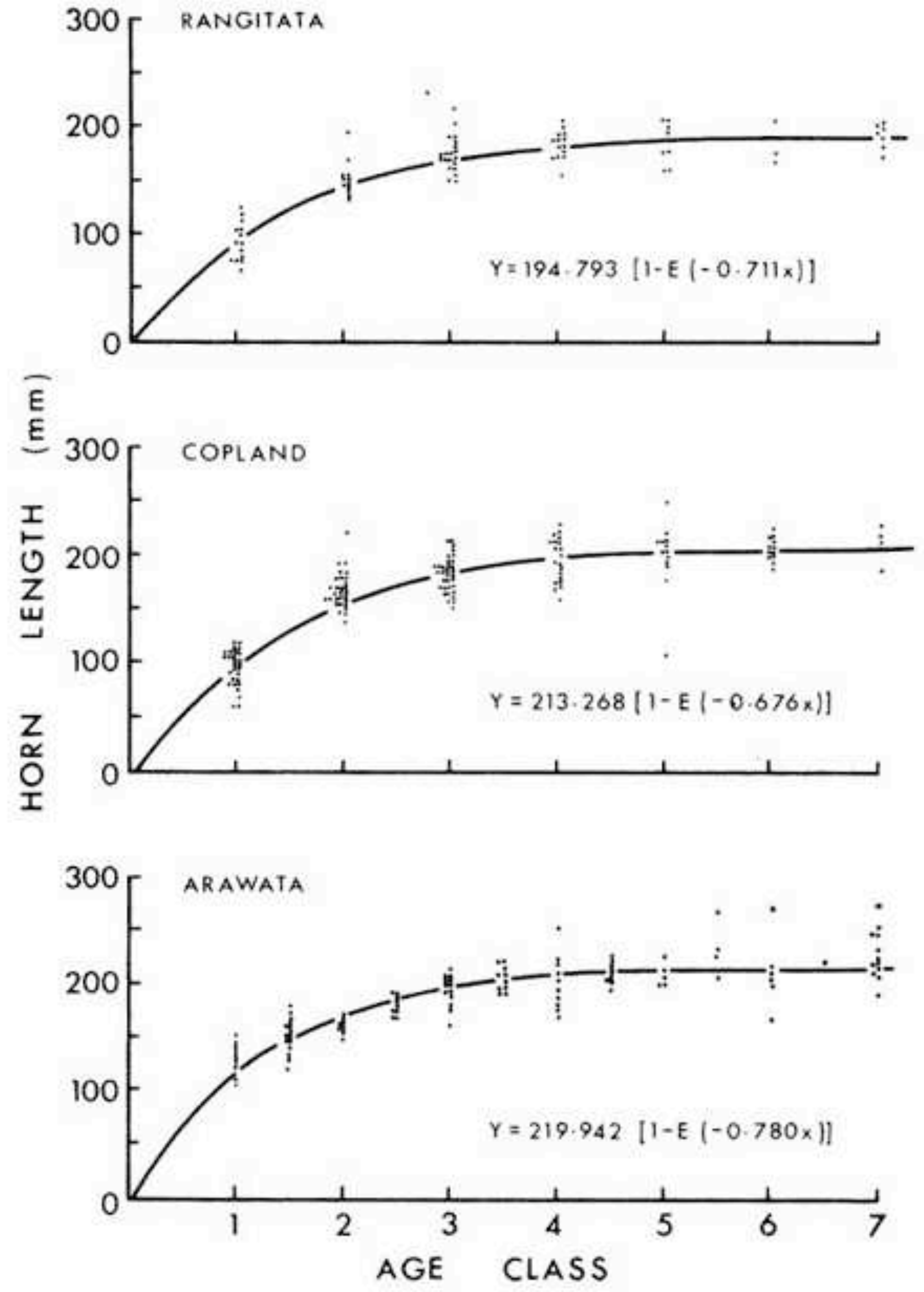

FIGURE 2. *Relationship of horn length with age for three chamois populations.*

proved significant at the 0.01 level in all cases: (Rangitata Fs = 6.98, Copland Fs = 6.82, Arawata Fs = 6.87). The regressions show that for comparable age classes there exists an upward gradation in mean horn size for the three chamois populations, in the order: Rangitata, Copland, Arawata (Fig. 2). A test of homogeneity revealed nonsignificantly different variance between the three regressions, (Fs = 0, D.F. = 188), enabling a valid combined horn length data regression, the equation being: $Y = 210.979 - 210.979\,E^{(-0.73472X)}$.

For comparison with the three New Zealand populations, female horn lengths were extracted from Schroder 1971 (Austria), and plotted against age class in Fig. 4. As age nomenclature between Austria and New Zealand differs by 6-9 months due to respective sampling periods, data were adjusted for this variation. The Austrian population, ("Schroders area three") has, except for age class 1, considerably smaller horn lengths than all three New Zealand populations for comparable age classes.

For all three New Zealand populations regressions of horn length for males show a similar form to that of females, but with the horns being longer, (Appendix 1). Male sample size limited further analysis, (N = 38, Arawata).

Total Body Length

Total body length data is summarized in Appendix II. Age for age, the one year old and younger Arawata females have slightly larger total body lengths that those from either the Copland or Rangitata, on the basis of unpaired T tests (Table 3). No significant differences exist for older animals. Unfortunately insufficient Arawata males were sampled to warrant analysis of male body length data.

Measurements of mean female total body length

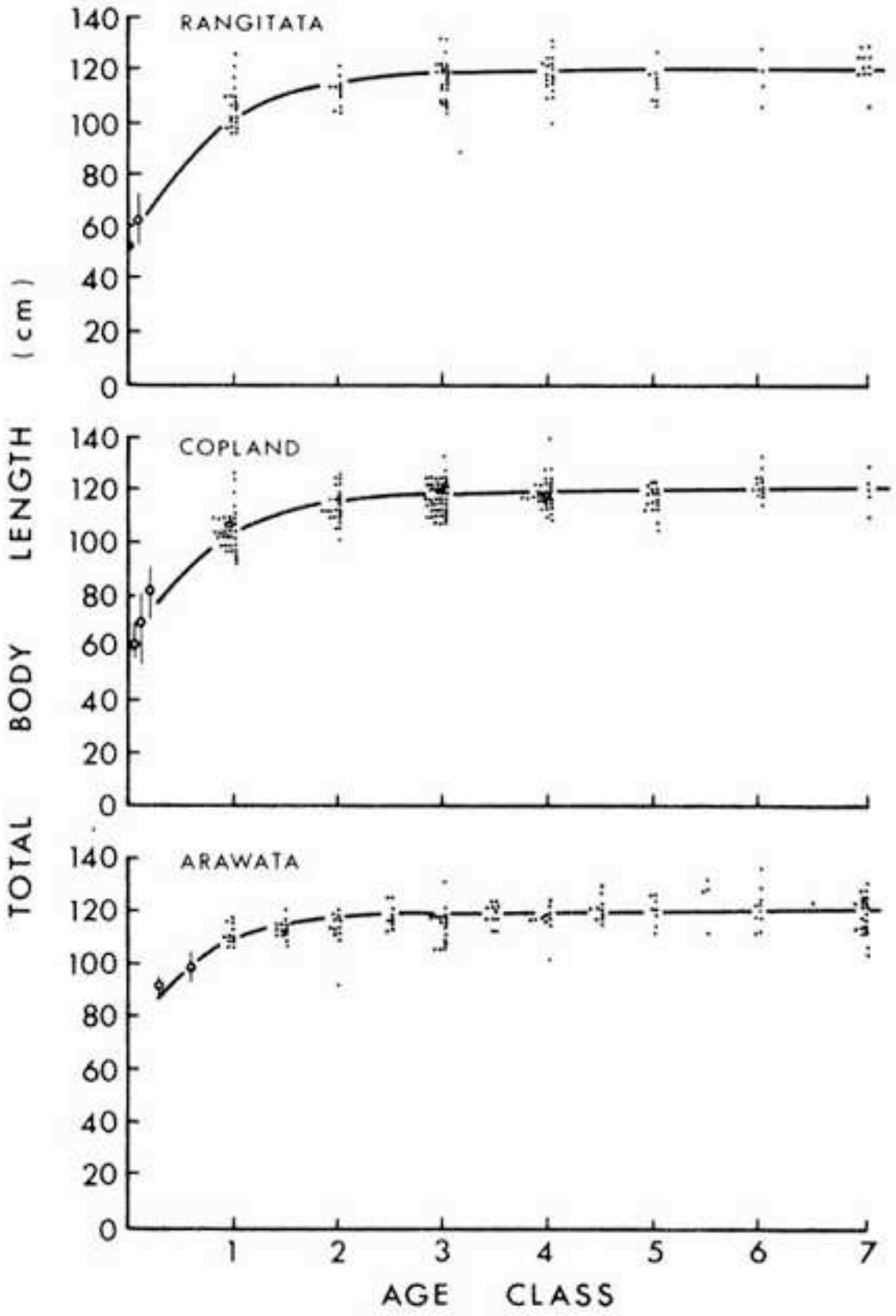

FIGURE 3. *Relationship of total body length with age for three chamois populations.*

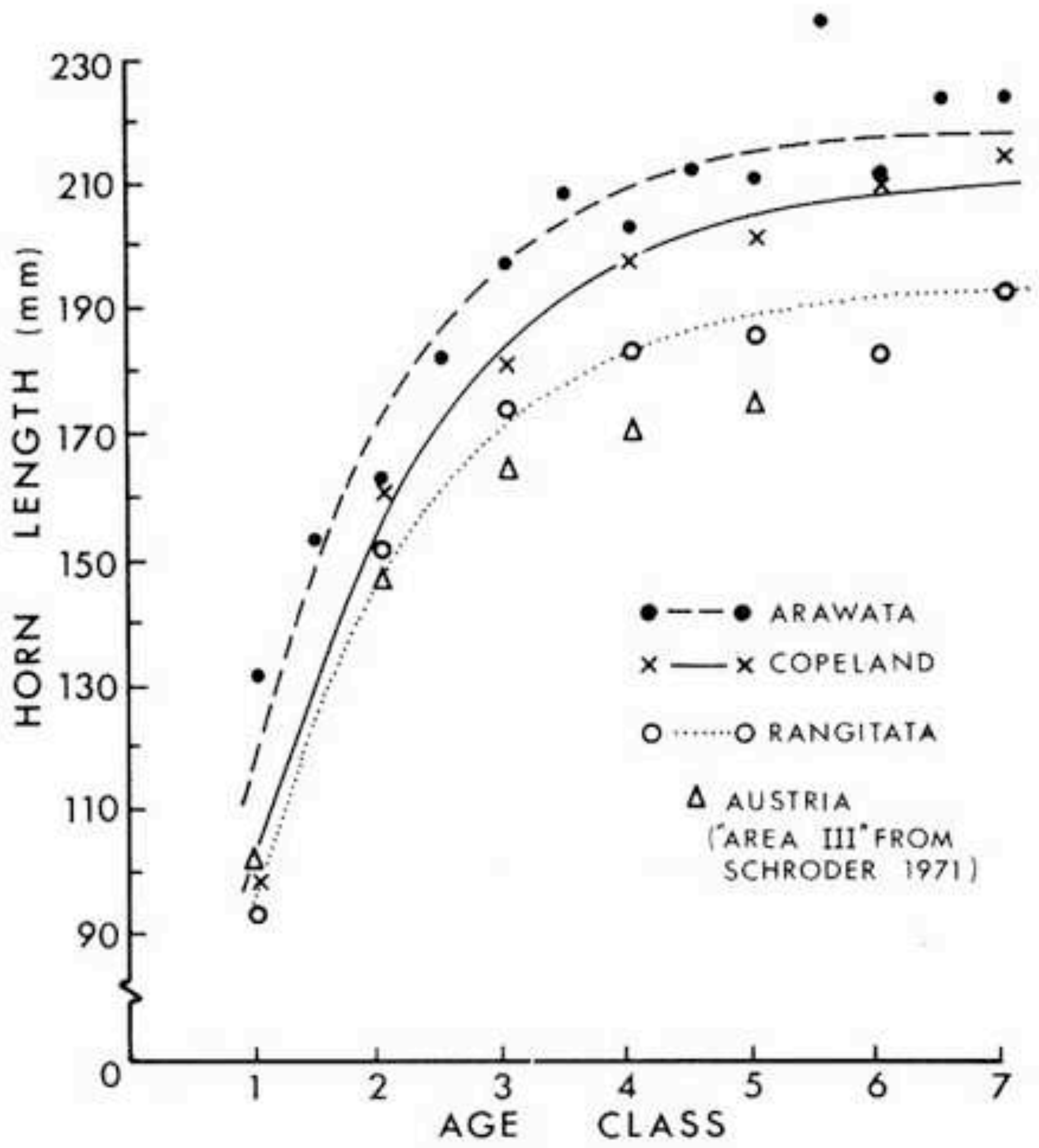

FIGURE 4. *Comparison of horn lengths plotted against age classes for three New Zealand and one Austrian chamois population.*

for each age class were tested for a significant regression of total body length with age (Fig. 3). This proved significant at the 0.01 level in all cases: (Rangitata Fs = 6.87; Copland Fs = 6.75; Arawata Fs = 6.80). A test of homogeneity revealed non-significantly different variance between the three regressions, (Fs = 0.097, D.F. = 493,), enabling a valid combined body length regression, the equation for which is: $Y = 118.16 - 118.166\ E^{(-1.43750\ (X\ +\ 0.518)}$.

TABLE 3. *T tests between mean total body lengths—Females.*

	Rang./Araw.		Araw./Copl.		Rang./Copl.	
Age class	T value	Level of signif.	T value	Level of signif.	T value	Level of signif.
0	20.14	*	8.26	*	4.01	*
1	3.08	*	4.38	*	0.61	N.S.
2	1.54	N.S.	0.67	N.S.	1.02	N.S.
3	0.15	N.S.	0.35	N.S.	0.13	N.S.
4	0.54	N.S.	0.24	N.S.	0.38	N.S.

* Significant difference at 0.01 level.

N.S. Non-significant difference at 0.01 level.

Weight Index

In an attempt to determine any differences in animal size between blocks within the Arawata survey area, a weight index for female animals older than 3 years was calculated from;

$$\frac{\text{Weight}}{\text{total body length}} \times \frac{100}{1}$$

Results are shown in Table 4. As sample numbers are very small the data from Waitoto and Okuru/Turnbull have been lumped, (means 36.0 and 35.4 respectively). An unpaired T. test revealed a significant difference between the Arawata and the remaining areas (Table 4).

Lactation Frequency

It was assumed that any female lactating had live kid/s at the time of sampling. The number of lactating animals which may have lost kids immediately prior to sampling was considered negligible. For the Arawata population, Table 5 shows the number and percentage of lactating females per age class, with those over age class 5 lumped. Table 6

TABLE 4. *Mean female weight/length index: by month* for three Catchments of the Arawata Survey Area.*

Area	Dec.	Jan.	May/ June*	Mean	T	Sign. level
Arawata	—	41.9 n = 3	41.0 n = 19	41.4 n = 22	5.58	Sign. at 0.01 level
Waitoto	—	33.6 n = 2	38.5 n = 3	35.6 n = 21		
Okuru/Turnbull	35.1 n = 7	35.2 n = 7	36.0 n = 2			

n = sample size.

* Samples from May and June lumped.

shows the total number and percentage of lactating adult females (2 years and older), per month, regardless of age class.

TABLE 5. *Percentage lactating Females; by age for Arawata sample.*

Age class	No. in sample	No. Lactating	% Lactating
0	18	0	0
1	19	0	0
2	11	3	28
3	20	13	65
4	17	14	82
5	7	5	82
6+	9	7	78
3+ (mature animals)	53	39	74

These figures indicate that lactation frequency does not decrease markedly with age or with the length of time following parturition, at least within the first seven months. This suggests that should lactation frequency be used as a measure of fecundity for comparison of different populations, data from all mature females (3 years and older), shot over a large part of the year could be grouped. Because of extremely small sample sizes for some months this conclusion should be accepted with caution. The zero slope of lactation frequency of mature animals when plotted against age class is consistent with the findings of Challies (1970) and Caughley (1971) for red deer. Challies grouped all animals nine years of age and older as the upper age class, and Caughley all animals ten years of age and older.

TABLE 6. *Lactation Frequency of 2 years and older Arawata Females, by Month.**

Month	Dec.	Jan.	March	May/June	Total
Total	2	8	15	40	65
Lactating	50%	62%	60%	67%	65%

* Months of May/June lumped.

Fecundity Rates

Female kids per female is calculated as percentage lactating females/2, assuming a 50:50 ratio of male to female kids. For the Arawata population (Table 7) there is no significant difference in fecundity rates between age classes from 3 upwards ($\chi^2=2.642$, P 0.01). However, the 2 year old age class has a fecundity rate significantly lower than the older age classes ($\chi^2=8.6609$, P 0.01). This suggests that fecundity data for females of three years and older could be grouped and population means compared.

Fecundity rate was also calculated from the number of female kids autopsied, compared with the total number of females of age 2 and over, as 0.2812 female kids/female. This is not significantly different from the overall average rate, 0.3281, calculated from lactating female/2 ($\chi^2=0.3328$, P 0.01).

TABLE 7. *Female kids per female: a comparison of the Rangitata/Copland (from Caughley, 1970) and Arawata samples.*

Area	Age in years							
	0	1	2	3	4	5	6	7
Rangitata/ Copland	0.0	0.0	0.136	0.325	0.411	0.357	0.389	0.368
Arawata	0.0	0.0	0.194	0.371	0.469	0.365	0.400	0.402

Caughley (1970) calculated fecundity rates for the combined Rangitata and Copland populations. As the two sets of data were not gathered during exactly the same months, analysis of the age class means is not valid. However it can be noted that the Arawata fecundity rates are slightly but consistently higher than their Rangitata/Copland counterparts, (Table 7).

DISCUSSION

When describing condition of a population, or discriminating between populations, it is efficient to use the measure of body size which has least within-population variance, yet which responds most rapidly to differences between populations.

Kidney fat indices (Riney, 1955), have not been included as a parameter for population comparison in this study because available evidence indicates that kidney fat reserves represent short term changes in food supply, (Riney, 1955, Caughley, 1970, Flux, 1971, Bamford, 1972); they present some difficulties of interpretation due to seasonal changes of kidney weight, (Batcheler and Clarke, 1971), and because the coefficient of variation is relatively large, (in the order of 50-70%, Batcheler, pers. comm.). For these reasons, and because chamois were sampled from different areas during different months, the K.F.I. was not considered.

The horn of chamois, with annual incremental growth rings (Couturier, 1938) theoretically possess a record of growth, year by year, over the animal's life. In New Zealand however, difficulty was experienced in determining the positions of the annual growth rings of chamois, so that horn annuli were considered undesirable for both ageing (Pekelharing, 1969), and yearly growth measurement. If the horn is considered as a single parameter of size similar to jaw, tooth row, hind foot and total body length parameters of size, it seemed reasonable to assume that differences in age specific sizes between populations would exist.

As horn growth begins only after birth (Couturier, 1938), and first external indications of horns appear at about 4 weeks of age, the nutritional plane of the kid after birth is the major factor in determining the rate of horn growth. It is therefore clear that the correlation between age-specific horn length of populations studied, and the relative ranking of their habitats, are good evidence that horn growth is an exuberant and sensitive measure of change in nutritive status of that population. This is analogous to the relative magnitude of change of antler size to body size which occurs in red deer (Huxley, 1932), after even short periods of changed food status, and suggests that generally, organs of lower importance to short-term survival of the individual are more sensitive to change of nutritional status, than are more vital organs, (Needham, 1964).

In contrast, these data (Appendix II), show that skeletal size of chamois, at least for females, is a poor indicator of adult animal condition. Differences between population means are generally of the same order as within-population variance. The error inherent in a measure of total body length is probably in the vicinity of 2-4 centimetres and accurate measurements depend largely on the degree of rigor mortis and the time taken by the observer.

Certainly, the lack of significant differences (Table 3), for adult females between areas of vastly different climate, topography, animal history and vegetation (the Rangitata and Arawata), establishes that mean total body length is a useless statistic for comparing populations of adult chamois.

The growth rate of immature animals is related to the plane of nutrition (Everitt, 1968, Fowler, 1968, Widdowson, 1968, and many others). This applies to foetal stages in growth as well as to post-natal growth. The interaction of the growing animal with its environment is particularly intense between birth and puberty (Fowler, 1968). This is supported by the significantly faster growth rate of Arawata females compared with those in the Rangitata and Copland, (Table 3); where the progression of mean body length per age class at the time of sampling is taken as a measure of growth.

For females, a large proportion of body growth takes place before sexual maturity is reached, as the stresses associated with gestation and lactation have a marked effect on the growth progression, giving the female an inherently smaller absolute growth rate, and a considerably shorter period of growth, than the male (Wood and Cowan, 1968). Accordingly, the rate of growth of juveniles suggested by age-specific mean total body length of the Arawata, Rangitata and Copland females, is significant evidence of a higher plane of nutrition in the Arawata, compared to the other areas.

All of the above point to the conclusion that differences in age-specific body size are only of use for indicating the mean plane of nutrition of adolescent animals. Samples taken at a number of distinct periods throughout the year enabling 3 monthly or 6 monthly, rather than yearly age classes, would be advantageous for constructing accurate growth curves of the immature animals. For mature animals, total body length would appear to give no indication of the level of animal, or population, plane of nutrition.

Inter-block analysis of the Arawata population revealed significantly different weight indices (Table [illegible]), between the Arawata and the remaining catchments, which is to be expected as the Arawata was the last of the three blocks to be colonized, although by only a few years. Although a comparison of fecundity rates between the Arawata and Rangitata/Copland populations is not strictly valid, the Arawata animals appears to have slightly but consistently higher fecundity rates for each age class (Table 7), which is consistent with a higher plane of nutrition.

In conclusion, of the four measures of body size investigated in this study, horn length appears to be the most useful for evaluating the mean planes of nutrition of chamois populations.

ACKNOWLEDGEMENTS

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Appendix I

Horn lengths (mm)

Age		*Female*			*Male*	
Class	N	Mean length	S.E.	N	Mean length	S.E.
	Rangitata					
1	15	93.5	18.0	25	108.9	20.3
2	12	152.5	16.6	17	181.9	21.2
3	20	174.3	17.1	11	200.9	13.6
4	14	183.9	13.1	9	215.7	35.2
5	8	186.4	19.5	1	213.0	—
6	3	183.3	—	3	218.3	5.9
7+	7	193.0	11.2	8	221.9	20.8
	Copland					
1	29	99.0	20.9	29	120.7	30.2
2	25	167.6	17.8	26	196.6	20.6
3	35	183.8	17.1	15	219.8	12.4
4	21	198.0	20.0	8	236.4	26.6
5	13	201.8	32.7	7	232.1	22.2
6	12	210.4	10.4	4	217.8	10.9
7+	5	214.8	15.3	3	232.3	28.8
	Arawata					
1	24	145.5	18.7	12	119.3	23.5
2	17	173.1	12.5	3	178.3	34.2
3	24	202.2	14.5	7	196.4	14.2
4	21	207.8	18.6	3	215.7	14.1
5	9	222.7	22.2	8	230.2	17.5
6	7	216.6	31.4	2	237.0	—
7+	12	224.0	23.2	3	240.7	17.8

Appendix II

Body lengths (cm)

			Females Only	
Age	Class	N	Mean length	S.E.
	Rangitata			
0		18	56.5	7.8
1		20	106.2	8.5
2		12	111.3	5.2
3		23	116.5	8.1
4		18	117.5	7.8
5		9	114.3	6.4
6		5	116.8	7.8
7+		10	119.8	6.4
	Copland			
0		50	70.5	14.0
1		37	104.8	7.6
2		25	113.4	6.5
3		46	116.7	6.1
4		33	118.2	6.0
5		18	115.9	5.3
6		14	121.2	4.6
7+		5	119.0	6.9
	Arawata			
0		18	98.2	4.0
1		25	112.0	3.9
2		21	114.8	6.8
3		27	116.2	5.9
4		23	118.6	5.2
5		12	121.3	6.5
6		10	122.0	6.8
7+		21	118.0	7.4

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