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OBSERVATIONS ON YEARLING MATING OF BEEF CATTLE

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SUMMARY

Relationships between joining age and liveweight and subsequent calving performance were studied from records of 9732 matings of Angus, Hereford and crossbred females including 1828 yearlings at four locations covering a range of grazing environments.

In all cases two-year-old cows marked over 50% live calves (range 52-76%). Between seasons each 10 kg increase in average yearling joining weight increased two-year calf production by 3%. Heifers above 193 kg at joining showed satisfactory calving performance at two years and older ages. Highest lifetime calf production was associated with yearling joining weights of 215 to 300 kg.

Relative to mature cows, two-year dams marked about 15% fewer calves owing to lower pregnancy rate and higher calf losses; their calves were born 1 to 2 weeks later and weighed 15 to 20% less at weaning. Except under very adverse conditions, two-year calving result was a useful indicator of performance at three years.

No physical damage accompanied joining of yearling heifers with mature bulls. Yearling bulls of 300 to 400 kg weight mated groups of 30 mixed-age cows as successfully as did older bulls.

Yearling mating is recommended in the interests of efficient calf production and faster genetic improvement, with a suggested minimum joining weight of 195 kg for heifers.

The mating of "yearling" (13-15 months) heifers could substantially increase total calf production from the beef herd provided it did not prejudice subsequent cow performance. It may also permit earlier recognition and culling of unproductive animals and, through possible reduction in mature size, increase feed conversion efficiency for calf production in later life. Earlier mating can accelerate genetic improvement through reducing the generation interval, particularly on the male side, and through greater selection intensity possible from increased calf numbers.

Despite these potential advantages, yearling mating is not commonly practised in either bull-breeding or commercial beef herds. Presumably existing feeding and management levels are deemed inadequate to sustain successful calving at two years of age without seriously impairing subsequent reproductive performance. Other deterrents are the expecta-

tion of calving difficulties, the fear of physical damage to lightweight heifers joined with mature herd bulls and the smaller size at birth and weaning of calves from two-year-old dams.

It is generally assumed that, for successful mating, yearlings must be well grown. For the British beef breeds in New Zealand minimum joining weights of 295 kg for heifers (Barton, 1964; Hight, 1968) and 340 kg for bulls have been suggested; in France (B. Vissac, pers. comm.) attainment of two-thirds mature body size is advocated, implying joining weights of about 460 kg for Charolais and Limousin heifers. A frequent recommendation also is that yearling heifers be joined only with yearling bulls. Barton (1959) advised mating yearling bulls to not more than 9 to 12 cows under run conditions.

These clearly restrictive recommendations are not well supported by factual evidence. Critical information is needed on the mating performance of yearlings and on the relationship between yearling joining weight and subsequent calving performance in beef cattle.

This paper summarizes relevant data from a number of experimental beef herds where yearling mating has been adopted. Certain limitations of the data, which are incidental to genetic studies involving selection and crossbreeding, should be recognized. They cover only a few environments and relate mainly to Angus cattle. They do not include details of nutritional status or of calving difficulties. Nor do they permit direct comparison of the lifetime calving performance of similar animals mated first as either yearlings or two-year-olds.

SOURCES AND DESCRIPTION OF DATA

The four experimental herds are located at Waikeria and at Tokanui, both about 40 km south of Hamilton, in the Waikato; at Waikite, 30 km south of Rotorua; and at Templeton, on the outskirts of Christchurch.

The land at Waikeria and Tokanui is fertile and undulating, the annual rainfall (about 140 cm) well distributed, but cool temperatures limit winter pasture growth. The experimental cattle, including steers finished for 21-month slaughter, share with sheep the grazing of pastures with a carrying capacity exceeding 15 ewe equivalents per hectare. Paddock sizes averaging about 8 ha permit semi-intensive grassland farming. Templeton comprises fertile flat land on the lower Canterbury Plains with a very high pasture production potential. Protracted dry weather tends, however, to restrict feed availability and animal performance in the summer. These three

locations can be considered representative of well-developed stud breeding or fattening farms.

By contrast, Waikite is typical of many North Island commercial beef breeding properties. The land is undulating to steep, with average altitude 420 m, but includes some flat areas. The soil is a pumice loam of volcanic origin, moderately fertile but deficient in certain essential elements. A long and severe winter with heavy frosts seriously limits pasture production and stock performance at this time. Cattle and sheep farming are integrated under an extensive grazing system; paddock sizes average 20 ha but vary up to 80 ha. Steers are not normally finished on the property, which is deemed capable of carrying 12 ewe equivalents per hectare.

Breeding experiments with Angus cattle at Waikeria have been outlined by Brumby *et al.* (1963) and Carter (1971). For present purposes they comprise three phases (see Table 2). In Phase I (1957-62) heifers were first bred to calve at three years of age, the bulls remained in the herd up to four months, and calves were identified at periodic marking dates when they were 3 to 7 weeks of age. Phase II (1962-67) marked the transition from a testing herd using brought-in bulls through to full establishment of the present closed breeding lines and associated test herd (Phase III). Heifers have been regularly bred as yearlings since 1961. For the 1962 calving the two-year-olds have been included in Phase II and the older animals in Phase I in which all heifers were first mated to calve at three years.

The experimental programme at Waikite commenced in 1968. The herd comprises both Angus and Hereford females which have been mated to bulls of the same two breeds to generate purebred and crossbred progeny. Most of the calving results reported here relate to purebred dams.

The research herds at Tokanui and Templeton, both of Angus females, were established in 1970 and 1971 as part of a breed evaluation programme in which bulls of local and overseas breeds are being progeny-tested in crosses with local stock. The use of artificial breeding in these herds coupled with inclusion of certain relatively large sire breeds conditions interpretation of the mating and calving results.

All sires used for natural mating have been paddock joined, each with about 30 cows of mixed age. Except for Phase I at Waikeria, mating was confined to an 8- to 10-week period in the spring, the breeding herds normally included a high proportion of yearling heifers, herds were pregnancy tested in the autumn, and calves were identified at birth and weaned at 4 to 6 months of age. Approximately 80% of all available heifers have entered the breeding herds, the lightest animals

usually being culled. After mating, heifers were normally separated and given preferential pasture feeding. Some non-pregnant 2-year-olds were initially brought into the herds; caution is necessary in comparing their subsequent performance with that of home-bred contemporaries.

For the present study cows failing to survive or losing their identification up to calving, or to prior diagnosis as non-pregnant, have been excluded. Matings to infertile or subfertile bulls, defined as those leaving less than 60% of their cows in calf, have been disregarded. Cows diagnosed as pregnant but having no record of subsequent calving, and those apparently conceiving more than 10 weeks after mating commenced (due to mis-identification after subsequent calving, as well as unobserved foetal or calf loss), have been recorded as "no calf". Calves born dead or dying within about six weeks of birth have been classified as "calf died". "Calving percentage" is defined as total cows calving or known to have aborted relative to cows mated and surviving. "Marking percentage" is based on cows with calves alive at six weeks (that is, ignoring twin births); subsequent calf losses to weaning were in most cases low, of the order of 1 to 3%. For the early years at Waikeria, calves marked in relation to cows joined provide the only measure of reproductive performance. All cow weights referred to in this paper were recorded at or shortly before joining, and do not include any adjustments for age or other factors.

RESULTS

AGE DIFFERENCES IN CALVING PERFORMANCE

Table 1 summarizes the information on joining weights and calf marking percentages according to location and age at calving, averaged over all years. In total the data cover 9732 (including 1828 yearling) matings whose outcome is known, after excluding 13 (4%) bulls classed as infertile or subfertile.

The more favourable conditions at Waikite relative to Tokanui are reflected in higher weights and marking percentages at all ages. Lower conception rates to artificial breeding largely account for the relatively poor calving performance at Tokanui and Templeton. At Tokanui the overall pregnancy rates in the artificially and the naturally bred groups, of similar cows, were 69 and 92%, respectively. The use of larger sire breeds also resulted in higher calf losses at Templeton (20%) and Tokanui (12%) than at Waikeria (6%) and Waikite (7%). Two-year-olds at all locations produced fewer live calves than mature cows, the difference tending to be greater with higher overall calving performance.

TABLE 1: OVERALL SUMMARY: JOINING WEIGHTS AND CALVING PERFORMANCE (see footnote)

<i>Location</i>	<i>Years</i>	<i>Age at Calving (yr)</i>							
		<i>N</i>	<i>2 W</i>	<i>M%</i>	<i>N</i>	<i>3 W</i>	<i>M%</i>	<i>N</i>	<i>4+ W</i>
Waikeria	16	1184	267	70	1313	361	79	3244	455
Waikite	4	335	226	65	573	293	76	1975	375
Tokanui*	2	259	253	66	294	301	70	358	392
Templeton†	1	50	266	58	108	329	66	39	394

*Half of matings by A.B.

†All matings by A.B.

Note: In this and the following tables:

N = Number of cows surviving to known outcome of mating.

W = Pre-mating weight (kg).

C = Total cows calving or aborting.

M = Cows with calves alive at normal marking age (6 wk).

TABLE 2: WAIKERIA: YEARLY MEANS FOR JOINING WEIGHT AND CALVING PERFORMANCE

Phase	Year	Calving Age (yr)															
		2			3			4			5+						
		N	W	C%	M%	N	W	C%	M%	N	W	C%	M%	N	W	C%	M%
I	1957	—				42	328	—	81	43	390	—	81	112	443	—	74
	58	—				76	338	—	78	58	67	—	79	163	422	—	72
	59	—				62	†	—	76	69	†	—	80	133	†	—	78
	60	—				70	340	—	86	59	378	—	95	139	416	—	92
	61	—				85	355	—	74	73	445	—	86	132	465	—	90
	62	(Phase II)				84	340	77	75	60	444	78	75	112	471	88	83
	Total					419	341	—	77*	362	407	—	84*	791	442	—	86*
II	62	103	256	80	71												
	63	118	267	76	71	106	370	80	75	90	440	86	83	60	484	87	85
	64	69	281	90	74	86	362	86	81	79	420	89	82	133	489	90	83
	65	106	244	70	53	79	377	81	76	78	431	90	82	163	489	86	82
	66	103	240	80	64	93	341	83	70	69	417	91	84	161	469	88	81
	67	120	277	86	67	87	358	85	80	64	424	92	89	156	478	89	87
	Total	619	260	80	66	451	362	83	76	380	427	89	84	673	481	88	84
III	68	110	277	89	76	94	376	93	88	65	441	89	85	142	495	94	89
	69	97	273	82	73	77	369	87	82	69	426	96	94	112	456	96	92
	70	122	288	88	76	91	399	89	84	76	457	95	92	147	505	93	88
	71	118	262	81	70	92	356	82	70	75	401	89	84	142	481	94	89
	72	118	272	81	71	89	387	91	83	64	449	91	83	146	513	94	88
	Total	565	274	84	73	443	378	88	81	349	435	92	88	689	491	94	89

*Excluding 1957 and 1958.

†Joining weights not recorded.

Yearly means for joining weights and calving performance at Waikeria are shown in Table 2. Reasons for the poor marking percentage from mature cows in the first two years are not known, and these results have been excluded from the Phase I average. Comparison of the results for Phase I in which heifers were first mated as two-year-olds (27 months) and Phase II where yearling heifers were bred indicates little average difference in calving performance at three years and older ages. In 1962 the three-year-olds out-produced the two-year-olds by only 4% calves marked, both groups calving for the first time. Since Table 2 shows little change in calving results from four years to older ages, these classes are combined in most subsequent analyses. Weights at all ages increased from the second to the third phase, presumably in response to the intense selection for high post-weaning gain or yearling weight, particularly on the male side. Calf production also increased, owing mainly to higher pregnancy rates in the later period.

Table 3 details the outcome of matings at Waikeria and Waikite classified according to age at subsequent calving. Clearly the principal reasons for the lower calf marking percentage of two-year-old and to a lesser extent three-year-old relative to mature cows are lower conception rate and higher calf losses. A study of birth weights of calves from two-year dams indicated a higher proportion of both below-average and above-average weights in those born dead relative to those alive. Excessively light calves were frequently premature, while heavy birth weights, particularly of male calves, tended to be associated with dystokia.

TABLE 3: DETAILED CALVING RESULTS (%)
Waikeria 1962-72 (Phases II and III) and Waikite 1969-72

	Age at Calving (yr)					
	Waikeria			Waikite		
	2	3	4+	2	3	4+
Non-pregnant	13	10	6
No calf	5	4	4
Aborted	—	2	1
Calf died	12	5	3
Calf "marked"	70	79	86
				65	76	77

CALVING PERFORMANCE IN RELATION TO YEARLING JOINING WEIGHTS

Table 4 summarizes for all four locations the average joining weights of yearling heifers classified according to their

TABLE 4: YEARLING JOINING WEIGHTS ACCORDING TO
TWO-YEAR CALVING RESULT
All locations

	Waikeria (1)		Waikite (3)		Tokanui (2)		Templeton (1)	
	%	W	%	W	%	W	%	W
	Non-pregnant	13	263	18	218	20	244	16
No calf	5	262	7	227	2	269	—	—
Calf died	12	270	10	239	12	250	26	259
Calf "marked"	70	267	65	227	66	256	58	269

two-year calving result. It provides little evidence of association between mating outcome and joining weight.

Yearly calving and marking percentages of two-year-old heifers at Waikeria (Table 2) are plotted against average joining weights in Fig 1. The graph clearly suggests a relationship between average joining weight and subsequent two-year calving performance, both the regressions shown being highly significant. On average, a 10 kg increase in yearling joining weights in any season results in a 3½% increase in two-year marking percentage. The corresponding regression of three-year calf marking percentage on two-year joining weight ($b = 0.2$)

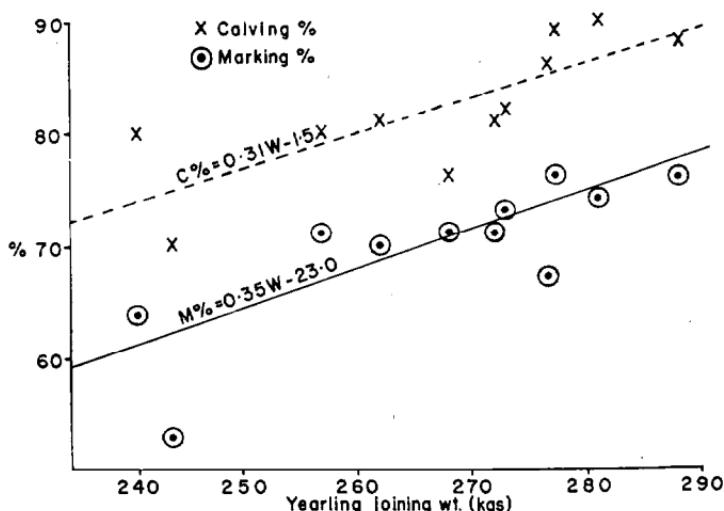


FIG. 1: Waikeria — Relationship between two-year calving and marking percentages and yearling joining weights (W). Yearly means 1962-72.

TABLE 5: TWO-YEAR CALVING PERFORMANCE OF LIGHTEST AND HEAVIEST 25% OF YEARLING HEIFERS
 Waikeria (1962-72) and Waikite (1969, 1970 and 1972)

	<i>Phase</i>	<i>Waikeria</i>		<i>Waikite</i>	
		<i>W</i>	<i>C%</i>	<i>M%</i>	<i>C%</i>
Total	II	260 { 267	80 { 82	66 { 70	75
	III	274 { 267	84 { 82	74 { 70	65
Lightest Quarter	II	230 { 238	86 { 84	74 { 71	65
	III	246 { 238	82 { 84	69 { 71	55
Heaviest Quarter	II	288 { 296	82 { 82	66 { 69	85
	III	304 { 296	82 { 82	72 { 69	74

approaches significance but no similar association is evident at older ages.

To investigate the relationship between joining weight and two-year calving performance *within seasons*, comparison has been made in Table 5 of the calf production of the lightest quarter and heaviest quarter of the heifers at joining, at both Waikeria and Waikite, results being pooled over seasons. At Waikeria, despite an average difference of 58 kg in joining weight, the lighter heifers produced and marked more (but not significantly so) calves than the heavier both during Phase II and overall. In contrast the heavier heifers at Waikite, where joining weights were in general much lower (see Table 1), significantly out-produced their lighter contemporaries ($\chi^2 = 7.9, P < 0.01$). The difference in marking percentage was greatest (38%) in 1968-9 when the yearlings averaged only 193 kg at joining and least (9%) in the following year with an average joining weight of 250 kg.

The relationship between yearling joining weights and subsequent calving performance as two-year-olds and three-year-olds is illustrated further for the Waikeria data in Fig. 2. Within each phase data for all years were combined, animals being classified according to joining weight. For Phase II marking percentage at both two-year and three-year calving is depressed for heifers below 215 kg at joining, owing mainly to higher calf losses (shaded areas in figure). Above this weight there appears little association between joining weight and calving performance, except that calf losses are highest when joining weights exceed 305 kg. Turning to Phase III, however, a different pattern emerges. Two-year marking percentage rises with increasing joining weight up to 260 kg. By contrast, calf losses to three-year old cows increase steadily with increasing yearling weights, resulting in a sharp drop in calves marked when yearling weights exceed 283 kg.

All cows entering the Waikeria herds during Phase II (*i.e.*, born 1960-1965) have now had the opportunity for at least six calving records if not previously culled. Two-year, three-year and lifetime calving performances for these animals are shown in Table 6, classified according to yearling joining weight. The average number of records, per cow first mated as a yearling, reflects in part culling based primarily on past reproductive performance. It should be noted that 88% of all the heifers were retained for a second mating as two-year-olds. Table 6 indicates that joining weights below 215 kg and above 305 kg are associated with lower lifetime calf production than weights in the intermediate range, within which there is little apparent relationship between initial joining weight and subsequent performance.

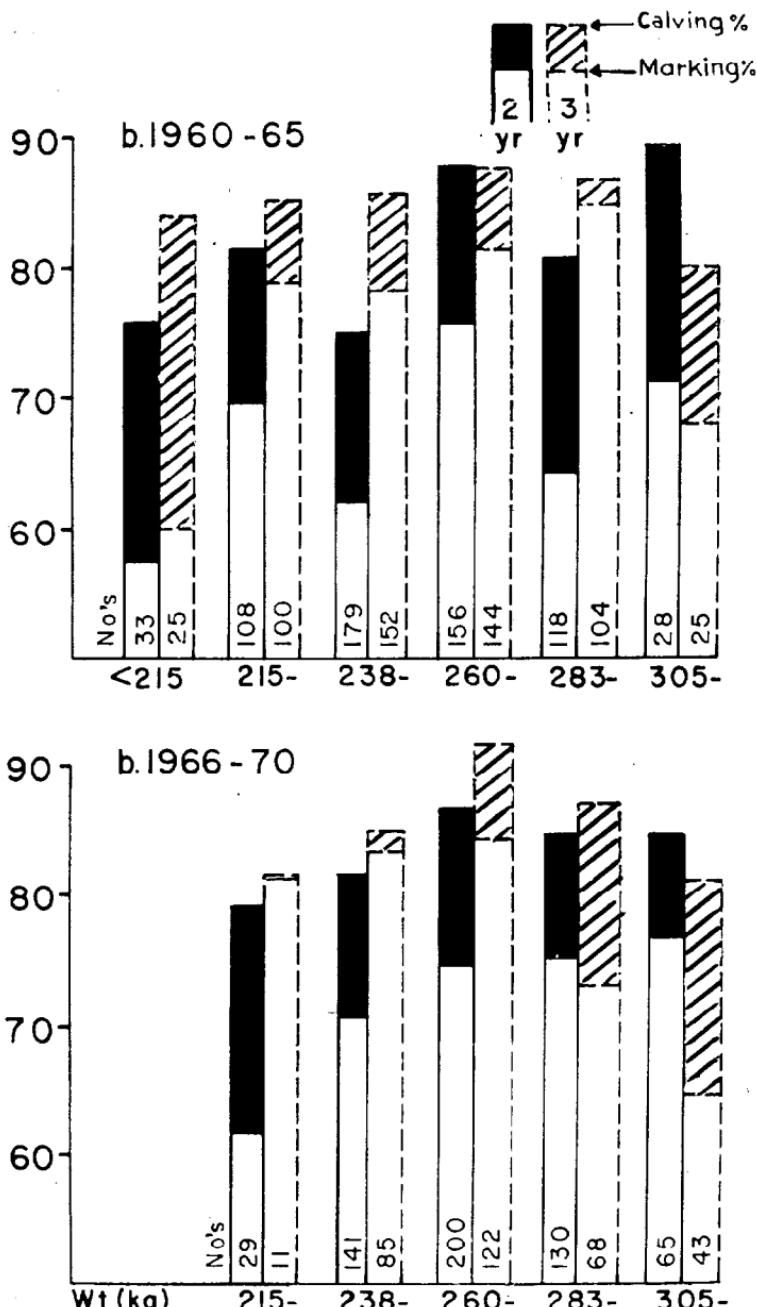


FIG. 2: Waikeria—Two-year and three-year calving performance in relation to yearling joining weight (kg). Phase II (heifers born 1960-65) and Phase III (born 1966-70).

TABLE 6: WAIKERIA: LIFETIME CALVING PERFORMANCE IN
RELATION TO YEARLING JOINING WEIGHT
Calves born 1960-65 (Phase II)

Joining Wt (kg)	No. of Heifers*	2 yr	Marking % 3 yr	Lifetime
-214	33 (3.1)	58	60	69
215-237	108 (3.7)	69	79	81
238-259	179 (3.5)	62	78	76
260-282	156 (4.0)	76	81	81
283-304	118 (3.9)	64	85	79
305-	28 (3.9)	71	68	70

*Average number of records per heifer joined in parentheses.

Wide seasonal variation in the results for Waikite, summarized in Table 7, precludes simple generalization. Exceptionally severe winter conditions in 1968 and again in 1970 seriously retarded growth of the young stock and depressed overall calving performance. In 1968, all heifers weighing above 175 kg were mated, their average joining weight being 193 kg. Overall, 77% were diagnosed pregnant and 58% produced live calves. Heifers below 193 kg at joining marked significantly fewer calves (45%) than those above this weight (75%). Satisfactory joining weights and conception rates were attained by the heifers mated in 1969. Their poor two-year-old calving performance, characterized by abnormally high (19%) calf losses, presumably reflected the stress of the severe intervening winter and was little influenced by variation in joining weights. At their second mating in 1970 these animals weighed on average only 21 kg more than when joined as yearlings. Despite light average weights of the yearlings joined in 1971 all except nine were above 193 kg and excellent subsequent calving results were achieved (76% calves marked).

The Hereford cows were heavier than the Angus at all ages. The Herefords produced fewer live calves at two years (owing to greater calf losses) but more at three years, with no overall breed differences in mature cow performance. Losses at or near birth were lower for crossbred than for purebred calves, both being born to purebred dams. At their first joining in 1971, crossbred heifers, both yearlings and two-year-olds, were heavier than purebred contemporaries and subsequently weaned more calves. Averaged over all seasons, pregnancy rates (marking percentages in parentheses) for purebred cows two years, three years and older at calving were 81 (62), 86 (75) and 87 (77) %, respectively.

TABLE 7: WAIKITE: JOINING WEIGHTS AND CALF MARKING PERCENTAGES

Year	Breed*	Age at Calving (yr)															
		2				3 (2nd calving)				3 (1st calving)				4+			
		N	W	C%	M%	N	W	C%	M%	N	W	C%	M%	N	W	C%	M%
1969	A + H	66	193	67	58	—	—	—	—	146	266	85	81	489	385	84	79
1970	A + H	107	250	71	52	52	308	67	64	99	308	83	70	544	402	83	75
1971	A + H	—	—	—	—	96	271	67	63	—	—	—	—	563	350	77	72
1972	{ A + H	115	220	78	74	—	—	—	—	132	310	91	86	379	358	88	86
	{ X	47	233	87	81	—	—	—	—	48	330	94	88	—	—	—	—
Total	A	156	220	71	64	84	282	61	58	275	286	85	78	1145	352	82	77
	H	132	230	75	61	64	315	75	69	102	310	92	86	830	406	83	77

*A = Angus. H = Hereford. X = reciprocal crosses.

TABLE 8: THREE-YEAR CALVING PERFORMANCE IN RELATION TO TWO-YEAR CALVING RESULT

	3 year 2 year	Waikeria (1963-72)			Waikite (1970-71)		
		N*	C% M%		N*	C% M%	
Calf "marked"	692 (94)	88	82	82 (95)	60	55
Calf died	94 (75)	84	73	25 (84)	84	84
Non-pregnant	47 (33)	75	64	24 (73)	79	67
No calf	19 (50)	47	42	12 (86)	83	58
Infertile bull	32	81	81			

*% heifers retained for second mating shown in parentheses.

THREE-YEAR PERFORMANCE IN RELATION TO TWO-YEAR CALVING RESULT

Three-year calving performance at Waikeria and Waikite is classified in Table 8 according to the outcome of the previous (yearling) mating. At Waikeria a high proportion of non-calving two-year-olds was culled before their second mating (all such heifers being culled in Phase III), those retained marking significantly fewer calves as three-year-olds than their contemporaries. On the other hand, the three-year calving performance of heifers whose first calves were born dead or died soon after birth was not significantly inferior to that of three-year olds who weaned calves at two years. Although few animals were involved, those run as yearlings with infertile bulls marked no more calves at three years than the remainder.

The results for Waikite, relating to only two birth-year groups, present a different picture. On average the poorest calving performance as three-year-olds was by those weaning live calves at two years of age, this effect being confined, however, to the 1968-born animals. For those born in 1967, the three-year calf marking percentage did not differ significantly among two-year outcome groups. Of 48 heifers born in 1968 and weaning calves in 1970, only 24 (50%) calved as three-year-olds in 1971 as compared with 86% calving among the remainder. Clearly lactational stress, aggravated by the harsh winter conditions in 1970, seriously impaired conception rate in these animals.

EFFECTS OF AGE AND WEIGHT OF BULLS ON CALVING RESULTS

Bull weights at joining and subsequent calf marking percentage from mates three years and older (*i.e.*, excluding yearling matings) are classified in Table 9 according to age and mating sequence, and include all phases of the Waikeria

TABLE 9: MATING RESULTS IN RELATION TO AGE AND JOINING
WEIGHT OF BULLS
Waikeria 1957-72

<i>Age</i> (yr)	<i>Mating</i>	<i>No. of</i> <i>Bulls*</i>	<i>W (Range)</i>	<i>C%†</i>	<i>M%†</i>
1	1st	86 (4)	361 (297-399)	89	88
2	1st	80 (5)	546 (374-678)	—	81
2	2nd	41	584 (465-667)	90	86
3	3rd	7	733 (669-853)	97	92

*Infertile or subfertile bulls, excluded from calving data, in parentheses.

†Based on all cows three years and older at calving.

programme. In terms of both incidence of infertile or subfertile bulls, and of resulting calf crop, home-bred yearling bulls, averaging 361 kg at joining, have proved superior to brought-in two-year-old "virgin" bulls averaging 546 kg. The latter comprised bulls chosen for either high or low weight gain from 9 to 21 months and differing on average by 84 kg; there was, however, little difference in their subsequent marking percentages. The untried yearling bulls performed in fact as well as older "tested" bulls, even with joining weights as low as 297 kg. Overall, no relationship has been noted between joining weights and calf-getting ability. The highest recorded joining weight was 853 kg. All bulls were paddock-mated with about 30 mixed age cows including (since 1961) a high proportion of yearlings. No case of physical damage to a heifer or cow has, however, been reported.

At Waikite yearling bulls, ranging in weight from 280 to 375 kg, have also demonstrated mating ability at least equal to that of the older bulls (weighing 420 to 735 kg). Nor has mating with bulls up to four times their own weight resulted in physical damage to heifers.

AGE OF DAM EFFECTS ON PROGENY PERFORMANCE

The influence of dam's age on progeny performance is illustrated in Table 10. Two-year dams calved on average nine days later than mature cows, the difference varying between seasons from 4 to 15 days.

At Waikeria calves from two-year dams on average weighed 13% less at birth, 17% at weaning, 9% at 12 months and 5% at 21 months (steers only) than progeny of mature cows. When corrected for age, however, the differences reduced to 13% lighter at weaning, 6% at one year, and 4% at 21 months. The maternal handicap incurred by calves from second calving

TABLE 10: AGE OF DAM EFFECTS ON PROGENY PERFORMANCE
 (Least squares estimate : all weights in kg)
 Waikeria, average of 8 years (calves born 1964-71);
 Waikite, average of 2 years (calves born 1969-70).

Age of Dam	M*	Waikeria		Waikite	
		M-2 yr†	M-3 yr†	M*	M-2 yr†
Birth date	8 Sep.	-9 days	-5 days	18 Sep.	-10 days
Birth weight	32	4	2	29	6
Weaning weight (Feb.)	185	32 (25)	14 (11)	150	40 (30)
Yearling weight (Sep.)	248	22 (15)	8 (5)	187	28 (18)
20 month weight (Apr.) — steers only	406	19 (16)	3 (2)	—	—

*M = mature cows (5 years and older at calving).

†Adjusted for age differences in parentheses

three-year-old dams was about half that from two-year-olds up to weaning, but substantially less thereafter.

Data from Waikite, limited to two calf crops only, reveal much greater weight differences between calves from two-year-old and mature dams, amounting to (age-corrected figures in parentheses) 21% at birth, 27% (20%) at weaning, and 15% (9%) at 12 months.

CONCLUSIONS AND DISCUSSION

The present evidence, although largely indirect, suggests that in normal seasons yearling mating of heifers does not affect calf production at three years and older ages. In these circumstances, calves from two-year-old dams represent a net gain from yearling mating. Oklahoma workers (Pinney *et al.*, 1962) reported that Hereford cows first bred as yearlings weaned in total 11% more calves in their lifetime than a contemporary group mated first at two years. In a more recent American study (L. V. Cundiff, pers. comm.), Angus, Hereford, Shorthorn and crossbred heifers averaging 290 kg weight at 13 months of age weaned 62% of calves as two-year-olds. At subsequent ages they actually weaned more calves than did genetically similar females calving first as 3-year-olds.

Under the favourable conditions at Waikeria which permit adequate nutrition in most seasons, highest lifetime calf production has been achieved by animals weighing 215 to 300 kg when joined as yearlings. Heifers weighing 193 to 215 kg nevertheless showed satisfactory lifetime performance, with

an average of 69% calves marked per joining. Yearling joining weights exceeding 300 kg were associated with higher calf losses and lower calf marking percentages at three years and older ages. Results from Waikite, more typical of commercial beef breeding conditions in New Zealand, suggest that even in adverse seasons yearling heifers may be profitably mated provided they exceed 193 kg liveweight at joining. Below this weight, although satisfactory conception rates can be achieved, effective calf production at two years is depressed and subsequent calving performance may be impaired.

It is concluded that yearling heifers above about 195 kg weight can in general be successfully bred to produce profitable extra calves. Given a standard deviation of 22 kg for yearling weights (Carter, 1971) an average joining weight of 230 kg should ensure than 95% of the animals in a group are above 195 kg. In contrast to beef herds, dairymen almost invariably mate their heifers as yearlings. In a survey among commercial dairy herds (Quartermain and Carter, 1969), weights of Jersey heifers in October averaged 195 kg with a range between herd means of 174 to 218 kg. All these herds achieved normal subsequent conception rates of the yearlings mated.

Between seasons, higher joining weights were associated with improved two-year and to a lesser extent three-year calf production. This could reflect merely common environmental factors influencing both yearling weight and conception rate, rather than an intrinsic physiological relationship. Within herd-years, yearling joining weight appeared to influence subsequent calving performance only below certain critical levels which may vary with seasonal conditions. Ellis (1970) related heifer pre-mating weight to subsequent calving percentage in a South Australian Hereford herd. He concluded that average yearling joining weights of about 272 kg were necessary to produce an 80% "calving". Relationships between mating weights and lambing performance in sheep have been widely studied. Coop (1962) concluded that barrenness was closely correlated with ewe liveweight up to a critical value (41 to 45 kg), with little association above this level. Coop and Hayman (1962) demonstrated and discussed a marked difference in the relationship between mating weights and lambing percentage among and within flock-years.

Two-year-old dams marked approximately 15% fewer calves than mature cows, owing to a lower pregnancy rate and higher calf losses. A similar overall difference was reported in Australian beef herds (Ellis, 1970). In an investigation of Hereford, Angus and Devon herds, Young (1968) noted that in only two of the 28 herd-years was pregnancy rate signifi-

cantly related to joining weight. Likewise, Laster *et al.* (1972) failed to establish any significant association between conception rate and weight at the start of the breeding period for yearling purebred and crossbred heifers.

Non-attainment of puberty would clearly influence pregnancy rate in yearling heifers. American studies (Wiltbank *et al.*, 1966; Short and Bellows, 1971; Laster *et al.*, 1972) have demonstrated marked effects of feeding levels and breed on the onset of puberty. Ages (weights in parentheses) at puberty ranged from 337 to 396 days (233 to 274 kg) for Angus and 390 to 457 days (269 to 306 kg) for Hereford heifers. The high pregnancy rates in relation to the yearling joining weights reported in the present study suggest that both age and weight at puberty in Angus and Hereford heifers under New Zealand grazing conditions are substantially lower than in U.S.A.

Although calving difficulties were not routinely recorded in this study, observation suggested that dystokia contributed more to calf losses from two-year dams in "good" than in "poor" years, whereas in adverse seasons low milk production caused increased early calf deaths from starvation. Young (1970) examined the influence on two-year calving performance of differential nutrition of in-calf Angus heifers whose joining weights averaged 230 kg. Despite a resulting weight difference of 76 kg at calving, feeding level had no apparent effect on the incidence of dystokia. Hight (1968), however, reported a marked reduction in calf weaning percentage from 3- to 8-year-old Angus cows subjected to a low plane of nutrition in late pregnancy (76% weaned) relative to a higher pasture feeding level (93% weaned). N. M. Wallace (pers. comm.) cited three New Zealand herds where yearling mating was abandoned because of resulting dystokia. The present evidence suggests that the high joining weights, averaging 272 to 318 kg, could have been in part responsible. In general, it appears that a moderate but not a high level of nutrition during rearing, pregnancy, and lactation is desirable for successful calving at two years of age and subsequently.

Little published information exists on repeatability of calving performance in beef cows. This study indicates that except under very adverse conditions a heifer's two-year calving result is a useful indicator of her performance at three years. Emphasis in culling should be placed on animals not calving at two years whereas those whose first calf fails to survive justify retention for further breeding. "Over-mating" of a high proportion of yearling heifers with pre-winter culling of those diagnosed non-pregnant is suggested as a useful means of increasing calf production efficiency.

Well-grown yearling bulls of 300 to 400 kg can be very successfully mated to groups of about 30 mixed-age cows, with conception rates likely to be higher than for brought-in two-year-olds. Likewise, yearling heifers may be joined with older and heavier bulls without serious risk of physical damage.

Calves from two-year-old dams were born 1 to 2 weeks later and were substantially lighter at birth (by 3 to 7 kg) and at weaning (23 to 36 kg) than those from mature cows. The weaning handicap declined with calf age and was approximately halved by two years. In a review of environmental statistics for growth traits of young beef cattle, Petty and Cartwright (1966) cite average differences between the progeny of two-year-old (three-year-old in parentheses) and mature dams of 4.4 (2.2) kg at birth and 29 (19) kg at weaning, in good agreement with the corresponding averages from the Waikeria experiments (Table 10).

On the basis of these findings, current recommendations on yearling mating in beef herds must be seriously questioned. Wider adoption of yearling mating of both heifers and bulls is urged in the interests of more efficient calf production and of faster genetic improvement. Under the conditions represented by the present trials, a minimum joining weight of 195 kg for heifers is suggested and joining weights above 300 kg should be avoided. Yearling heifers may be safely joined with mature bulls and yearling bulls successfully mated with groups of 30 mixed-age cows. A need clearly exists, however, for more critical study of the influence on reproductive performance of different feeding levels and consequent weight changes at different stages in the growth and development of beef females.

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