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Improvement of Beef Cattle Productivity with a Combination of New and Conventional Breeding Methods

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Abstract
A simulation model is formulated to evaluate productivity of the cattle on an imaginary farm. The model is designed to establish an effective system covering the cattle production through fattening of calves from beef cattle. Efficiency of the modified conventional production technique is examined by increasing the conception rate of breeding cows and shortening the calving interval. It is proposed that the modified conventional method be combined with a new technique which employs an embryo transfer treatment to produce twins in an artificial way. The results based on the proposed model suggest that there be a potential for improving productivity of beef cattle with such a combined method.

Discipline: Animal industry
Additional key words: calving interval, conception rate, embryo transfer, production system, simulation model

Introduction

Future demand for beef in Japan is expected to increase by 4 to 5% each year on a mid-term basis. To meet such demand with an increased domestic production, though accompanied partly by imported beef, it is prerequisite to raise productivity and production of beef in the country. In the present beef market in Japan, approximately 70% in weight of dressed carcasses come from dairy cattle, while only 30% from beef cattle[4]; thereby the production of milk is adjusted to prevent oversupply to the market. In this situation, it is reasonable to forecast that no substantial increase in the number of dairy cattle could be attained in the foreseeable future in Japan. National programs including research for new technology development are presently undertaken to increase the number of beef cattle and to improve cattle calving technologies as well. The farmers are strongly encouraged to adopt the new technologies developed through national and regional livestock programs[1].

The breeding work of beef cattle in Japan is split into two sectors; i.e. one is calf producers and the other is farms that fatten calves. There is a conflict of interests between these two sectors in the cattle market, because the calf producers want to sell the calves at a high price to maximize their profits, while the farms fattening calves want to buy those calves at a low price possible. This situation discourages the efforts of both sides in reducing the production costs of beef. To establish a beef industry which is strong enough to be competitive in international markets, strenuous efforts must be devoted to the following aspects of beef cattle production[5]: (1) present production techniques will have to be greatly improved to raise productivity of beef cattle; (2) both the calf producers and the fattening farms have to cooperate in reducing production costs; and (3) a new system for production has to be established.

The present paper shows effects of a combined method of the conventional breeding technique designed to improve the conception rate and shorten

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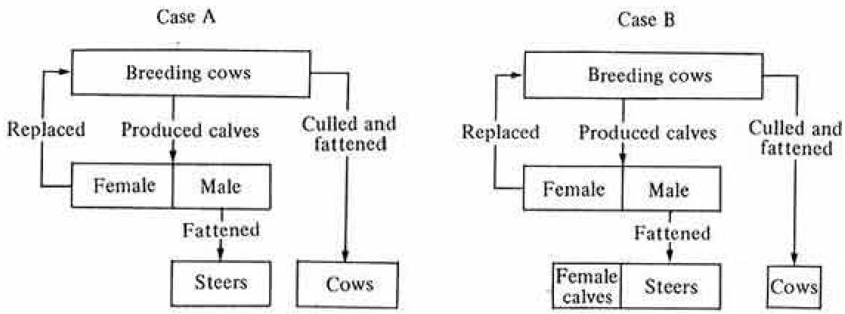


Fig. 1. Farm model of beef cattle production

the calving interval, with a new production technique designed to produce twins by using an embryo transfer (ET). This combined system has been tested under a simulation model of production farm where the calves are produced and fattened in the same farming unit.

Materials and method

A simulation model is formulated to evaluate productivity of the cattle group that is produced in a systematic way covering a whole cycle from the production through the fattening of calves of beef cattle. In the production model, the following two cases are conceptually set up: case A where all fertile female calves born are used for breeding; and case B where only female calves needed to replace cattle are used for breeding and the remaining portion of the female calves is used only for fattening (Fig. 1). To produce twins, cows are artificially inseminated, being followed by the ET treatment a week later.

The productivity of calves (S) can be expressed by the following equation:

$$S = (1-Mt)Sa(1-Ma) + \{Sa(1-SeMe)(1-Ma) + Se(1-SaMa)(1-Me)\}Mt$$

where Sa = Final conception rate of cows,
Ma = Rate of death and abortion,
Mt = Rate of implementation of ET,
Se = Conception rate with ET,
Me = Rate of death and abortion using ET.

ST calves are produced from T breeding cows. Half of these calves are male; they are castrated and fattened. The number of the castrated calves to be fattened can be expressed by the following equation:

$$(1-Mi)(1-Mp)ST/2$$

where Mi = Rate of accident during raising,
Mp = Rate of accident during fattening.

Female calves are used for breeding, while freemartin heifers are fattened.

Abortion and calf mortality are higher for twins than for monotocous births. A survey undertaken by the authors indicates that Me is 10% and that Mi for twin calves is 12%.

Feed requirements and production of dressed carcasses are estimated on the basis of result of the survey on the farms, where beef cattle were produced in a systematic manner as earlier mentioned. DM and TDN of the feed are calculated from the standard table of feed composition[2]. The amount fed is compared with standard values presented in the Japanese feeding standard[3].

The dressing percentage of castrated bulls is 61.3%. The age of cows when the fattening is terminated varies widely because the fattening starts only after the cows have been used for breeding purpose. The dressing percentage of cows is determined from the regression equation of $Y = 61.88 - 0.063X$, where X is the age in months when the fattening is terminated.

The unit price of dressed carcass from castrated bulls is ¥1,800 per kg. With increasing calving numbers, the price from cows would be lowered by ¥100 per kg. The costs of feed are determined on the basis of prices of commercial feed. The average costs of TDN are ¥77 per kg for breeding cattle and ¥60 for fattening cattle.

The following items are included in the indices of the production of cattle: TDN required per year, production of dressed carcass, costs of feed required to produce one kg of dressed carcass (feed cost required for dressed carcass production), and TDN required to produce one kg of dressed carcass (TDN requirement). With less costs of feed for dressed carcass production and TDN requirement, higher productivity can be attained.

Results and discussion

1) *Improvement of the productivity of cattle by the conventional breeding method*

It is generally recommended to use cows as long as possible while they can be available for breeding. A survey on the breeding cows showed that the cows of up to six calvings accounted for 76% of all the cows with a mean of 4.7 calvings. The mean calving interval was 13.6 months.

Table 1 shows the production of cattle, which is estimated on the basis of the above premise with T = 30 breeding cows. The indicative figures regarding the cows which are used for breeding up to six calvings are close to the present status, provided that they are thereafter slaughtered for beef with an Sa of 80% and a calving interval of 14 months.

If Sa is of the same value, there are no significant differences in the production of dressed carcass between the two cases; A and B. The case A requires less TDN than the case B. This result implies less feeding costs in the case A, where costs for dressed carcass production and TDN requirement are lower than the case B. With an Sa of 80%, the TDN requirement is 1.5 – 1.8% less in the case A than in the case B. With an Sa of 90%, the TDN requirement is 3.3 – 4.0% less.

The case A contains no heifer because all female calves are used for breeding and a majority of cows are fattened after use for breeding. In the case B, on the other hand, female calves which can be used for breeding are also fattened. When the female calves are fattened, TDN accumulated throughout the period from breeding to delivery is consumed for fattening. When the cows are fattened, beef is produced with TDN accumulated during the period after the use for breeding is terminated. This explains the reason why the TDN requirement in the case A was less than in the case B.

With an improvement of Sa from 80 to 90%, the production of dressed carcasses and TDN required per year increase, and the feed costs required for dressed carcass production and TDN requirement also increase in the case B. This indicates that an Sa of 80% provides better productivity of dressed carcasses in the case B. In the case A, however, with an improvement of Sa from 80 to 90%, the production of dressed carcasses and TDN required per year increase, while feed costs required for dressed carcass production and TDN requirement are reduced.

In the case B, the improved Sa increases the number of female calves to be fattened, while it decreases the number of cows for fattening. In the

Table 1. Productivity of beef cattle by the conventional techniques

Calving interval (months)	14				12			
Case	A	B	A	B	A	B	A	B
Final conception rate of cows (%)	80	80	90	90	80	80	90	90
Total number (head)	73.7	75.1	81.9	85.0	82.3	84.3	91.3	96.3
TDN per year (ton)	103.7	105.1	115.2	118.2	106.3	108.5	118.1	123.2
Number of castrated calves (head)	10.1	9.9	11.4	11.1	11.1	11.1	12.5	12.5
Number of fattened heifer calves (head)	0.0	2.5	0.0	5.3	0.0	2.7	0.0	5.8
Number of fattened cows (head)	10.1	7.6	11.2	6.0	11.4	8.6	12.8	6.8
Dressed carcass per year (ton)	7.37	7.36	8.26	8.20	8.17	8.18	9.19	9.21
Feed costs for dressed carcass (yen)	939	950	933	958	900	914	890	920
TDN requirement (kg)	14.07	14.28	13.95	14.42	13.01	13.26	12.85	13.37

Total number of breeding cows is 30.

case A, however, the improved Sa increases the number of cows fattening, which produce beef efficiently because of the absence of the female calves to be fattened. In the case A, with an improved Sa, the productivity of dressed carcasses also increases.

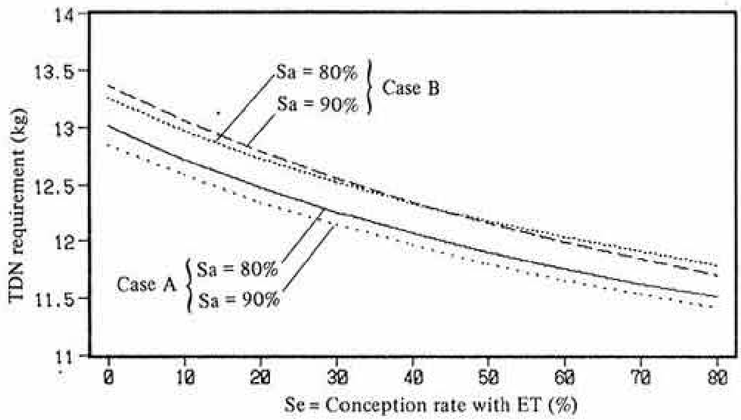
Since females are basic livestocks to produce their calves, farms are not encouraged to fatten the female calves. In practice, however, the female calves are not rarely fattened without any use for breeding. It is estimated that approximately 60% of the female calves produced in 1988 were fattened in this way. Unlike the dairy cattle, the beef cattle are bred only to produce beef. In order to improve the productivity of beef cattle in Japan, it is important that great efforts be made to attain the maximum productivity of beef from fattened cows, following the use in breeding as done in the case A.

2) *Improvement of the productivity of cattle with ET*

Under the natural conditions, it is not so frequent that beef cattle produce twins; according to the survey in the United States, no breed exceeds a production of twins of 5%[6]. On the other hand, the treatment of ET has a potential to increase the production of twins in an artificial manner. However, this technique has not become popular in Japan because it requires skills for treatment and is rather costly. If such problems could be solved, the potential for increasing significantly the production of calves of monotocous animals would be materialized in beef cattle farming. The present paper proposes an idea of the improved production of calves with an adoption of the ET method.

As the Se increases, number of total cattle, TDN required per year, number of cattle delivered, and production of dressed carcasses increase (Table 2). The TDN required per year and production of dressed carcass of the total cattle are higher with an Sa of 90% than the case of 80%. A sum of the castrated and heifer claves that are fattened is higher in the case B than in the case A. In regard to the interaction between the number of the cows fattened after the use for breeding and the level of Sa, the number slightly increases with an Sa of 80% and decreases with a 90% Sa in the case A, which is contrary to the case B.

As the Se increases, the TDN requirement decreases with a trend of the gradual declining curve (Fig. 2). The TDN requirement is lower in the case A than in the case B. In both cases, the requirement declines as the Sa increases. In the case B, the TDN requirement is low under the Sa condition of 80% when the Se is within 40 – 50%. However, it is low with an Sa of 90% in case where the Se exceeds 50%.



Sa : Final conception rate of cows (%)
Se : Conception rate with ET (%)
ET : Embryo transfer

Fig. 2. TDN requirement as a function of the conception rate with ET (%)

Table 2. Productivity of beef cattle with embryo transfer

	Sa*(%)	Case	Se**(%)								
			0	10	20	30	40	50	60	70	80
Total number (head)	80	A	82.3	88.2	94.0	99.9	105.8	111.6	117.5	123.3	129.2
		B	84.3	90.4	96.5	102.6	108.7	114.7	120.8	126.9	133.0
	90	A	91.3	96.9	102.4	108.0	113.5	119.1	124.6	130.2	135.7
		B	96.3	101.7	107.2	112.7	118.1	123.6	129.0	134.5	139.9
TDN per year (ton)	80	A	106.3	113.2	120.0	126.9	133.8	140.6	147.5	154.3	161.2
		B	108.5	115.6	122.7	129.8	136.9	144.0	151.1	158.2	165.3
	90	A	118.1	124.4	130.8	137.2	143.5	149.9	156.2	162.6	168.9
		B	123.2	129.5	135.7	142.0	148.3	154.6	160.9	167.2	173.5
Number of castrated and fattened heifer calves (head)	80	A	11.10	12.90	14.70	16.60	18.40	20.20	22.10	23.90	25.70
		B	13.80	15.90	17.90	20.00	22.10	24.10	26.20	28.20	30.30
	90	A	12.50	14.40	16.30	18.20	20.10	22.00	23.90	25.80	27.70
		B	18.30	20.10	21.90	23.70	25.50	27.20	29.00	30.80	32.60
Number of fattened cows (head)	80	A	11.4	11.5	11.5	11.5	11.6	11.6	11.7	11.7	11.8
		B	8.6	8.4	8.2	8.0	7.8	7.6	7.4	7.3	7.1
	90	A	12.8	12.7	12.6	12.5	12.4	12.3	12.1	12.0	11.9
		B	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Dressed carcass per year (ton)	80	A	8.17	8.90	9.63	10.36	11.09	11.82	12.55	13.28	14.01
		B	8.18	8.91	9.64	10.37	11.10	11.83	12.56	13.29	14.02
	90	A	9.19	9.89	10.60	11.30	12.00	12.70	13.40	14.11	14.81
		B	9.21	9.91	10.61	11.31	12.02	12.72	13.42	14.12	14.82
Feed costs of dressed carcass (yen)	80	A	900	876	856	839	824	811	799	789	780
		B	914	890	871	854	839	826	815	805	796
	90	A	890	868	849	832	817	804	792	781	772
		B	920	895	874	855	839	824	811	799	788
TDN requirement (kg)	80	A	13.01	12.72	12.47	12.25	12.06	11.90	11.75	11.62	11.51
		B	13.26	12.97	12.72	12.51	12.33	12.17	12.03	11.90	11.79
	90	A	12.85	12.58	12.34	12.14	11.96	11.80	11.66	11.53	11.41
		B	13.37	13.06	12.79	12.55	12.34	12.16	11.99	11.84	11.70

* Sa: Final conception rate of cows (%). Total number of breeding cows is 30. ** Se: Conception rate with ET (%).

For the purpose of keeping a constant number of cattle, all the slaughtered cows must be replaced. In the case A, the number of the female calves for replacement is not necessary to be taken into account, since all the female calves produced are assigned to the breeding group for replacement. In the case B, however, the female calves have to be secured for mating to replace the cows slaughtered.

The production of twins with an ET to obtain more female calves for replacement causes a problem of free-martins. In case where a pair of different sexes are produced, the female calf cannot be used for breeding; it has to be fattened. Out of the calves produced with an Sa of 80%, the number that can be used for breeding is 11.4, 11.5 and 11.7 with an Se of 0%, 30% and 60%, respectively, indicating a slight increase. However, with an Sa of 90%, the number for the same purpose is 12.8, 12.5 and 12.1 with an Se of 0%, 30% and 60%, respectively, showing a decreasing trend. This suggests that with an increased Sa, there be a tendency that the cows which produce twins increase in number, though to a small extent, and female calves that cannot be used for breeding also increase.

With an Se of 60%, the TDN requirement is a range of 11.7 – 12.0 kg, whereas it is 12.9 – 13.4 kg with an Se of 0%; this implies an improvement by 9.3 – 10.3% in the former case. Even without the ET treatment, the TDN requirement is 12.8 kg in the case A under the condition of an Sa of 90% and a calving interval of 12 months. This means a 10% improvement compared with the TDN requirement in the case B with an Sa of 80% and at a calving interval of 14 months (Table 1).

This suggests that there be a need for reviewing the conventional techniques of beef cattle production and identifying appropriate conditions for raising beef cattle so that the calving interval could be shortened until a new production technique such as ET could be in a practical use.

Conclusion

The results obtained on the basis of a proposed simulation model suggest that there be a potential for improving productivity of beef cattle with a combined system of conventional and ET methods. However, it might take some more time to establish an appropriate production system, including an effective ET treatment, for a practical use. The present study therefore indicates that there would be a great need for thoroughly reviewing the conventional breeding technique in general, the calving interval in particular, and for developing a less costly treatment of ET.

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