A Fencing System Based on Cattle Behavior

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Introduction

A fence is one of the important facilities to manage cattle on the pasture. All the grazing systems in the public pastures of Japan have extensively operated with an installation of barbed wire fences. During the summer season, the public pastures afford a large number of grazing cattle entrusted by the farmers who raise several cattle each. On the pastures, the cattle are under the health care and prevented from escaping over the fence. The fencing system is presently standardized, comprising a number of posts with an interval of 4 m each and 4-barbed wires with a spacing of 30 cm each above the ground. The materials of fences are also standardized, consisting of steel posts with a 1.8 m length each and galvanized barbed wires. Such a system and materials of fence, however, have been designed without any consideration on the behavior of cattle to be raised in the fenced areas. The well-developed countries in livestock industries such as U.S.A. and New Zealand have established suitable fencing systems on the basis of their long experience, while the designs of fencing systems deployed in Japan are merely the transfer from those countries. No improvements have been made since the inception of the national grassland development program in 1965. The layout of fence line and disposition is uniform throughout the country and fence damages caused by snowfall take place not rarely in the snowy area of Japan[2,3]. A suitable fencing system including materials, structure and layout of fences should therefore be developed so that it fits in the cattle behavior and the steep and uneven topography of Japan.

The behavior of cattle escaping from the fence is usually associated with the time when the cattle stick into the wire space of fence while grazing on the pasture. In such a case, it is required that the fence has an adequate function to prevent the cattle from grazing outside the fence. The barbed wire fences presently used in Japan function only depending on the barbs of the wires. Effectiveness of this fencing system, or a functional index, is heavily dependent on tension and number of wires, post interval and wire spacing. This paper presents a proposed fencing system which would have more adequate function to prevent the cattle from grazing outside the fence and fit with the cattle behavior on a sloping pasture.

Post interval and wire spacing to prevent the cattle from grazing outside the barbed wire fence

The present experiment contained several types of fence structures, under which the following four cows were raised: two Japanese Shorthorn cows with mean withers height of 127 cm and mean body weight of 456 kg; and two Japanese Black cattle cows with mean withers height of 126 cm and mean body weight of 395 kg. The experimental fences had post intervals of 2, 3, 4, 6, 8 and 12 m with 3-barbed wires of 40, 80 and 120 cm high each above the ground, 4-barbed wires of 30, 60, 90 and 120 cm high each and 5-barbed wires of 40, 60, 80, 100 and 120 cm high each. The grazing experiment was repeated three times; each grazing period was 180 sec per treatment in each fence type

under the post interval of 2 m with 3-barbed wire for two Japanese Shorthorn cows. In each experiment, a concentrated feed of about 1.5 kg was laid on a vinyl sheet which was placed in a row approximately 90 cm apart outside the fence line. The frequency and duration of sticking into each wire space were counted for each cow and fence type. The wire tension was kept at 20 kgf in each experiment.

Mean frequency and duration of grazing outside the fence per cow are indicated in Fig. 1. A greater frequency of grazing outside the fence was seen in Japanese Black cattle as compared with the case in Japanese Shorthorn. No clear-cut difference of outside grazing existed among the post intervals. Regarding the duration of outside grazing Japanese Black cattle was shorter than Japanese Shorthorn. The duration difference among the post intervals was also not clearly seen in both cows. In regard to the grazing behavior, the cows grazed more frequently for a shorter period under the wire space with a narrower post interval, as compared with the case in a wider post interval. Therefore, effectiveness of the fencing system in preventing the outside grazing should be evaluated on the basis neither of frequency nor duration itself of grazing outside the fence, but of product of these two related factors, or of multiplied time. The multiplied time based on the experiment is shown in Fig. 2. The results indicate that the functional indices to prevent from grazing outside the fence increase as the post interval becomes wider. In this respect, it is recognized that Japanese Black cattle is more strongly prevented than Japanese Shorthorn is under the experimental fencing conditions.

Regarding the responses to the wire height in the fencing system, the cows grazed easily outside the fence under the conditions of 40–80 cm in 3-barbed wire fence, 30–90 cm in 4-barbed wires, or 0–60 cm in 5-barbed wires (Fig. 3). Since the cattle grazed in falling on their knees under the fence of 40 cm high in 5-barded wires, the lowest wire height should be at least about 30 cm above the ground. This result indicates that it is necessary to install the wires with narrow space, which should be adequately designed on the basis of cattle withers height. In this experiment, it will be

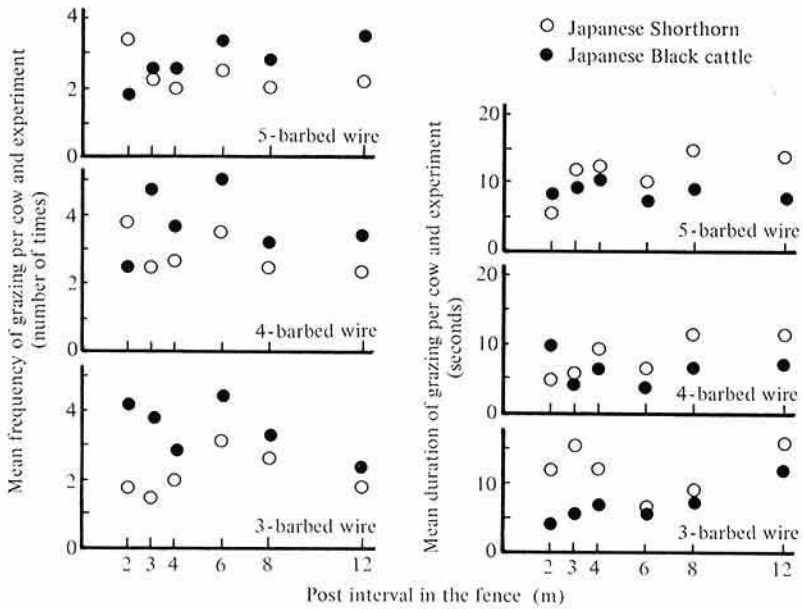

Fig. 1. Mean frequency and duration of grazing by cows and experiments
The experiments were repeated three times with each cow.
The duration of grazing was 180 sec in each experiment.

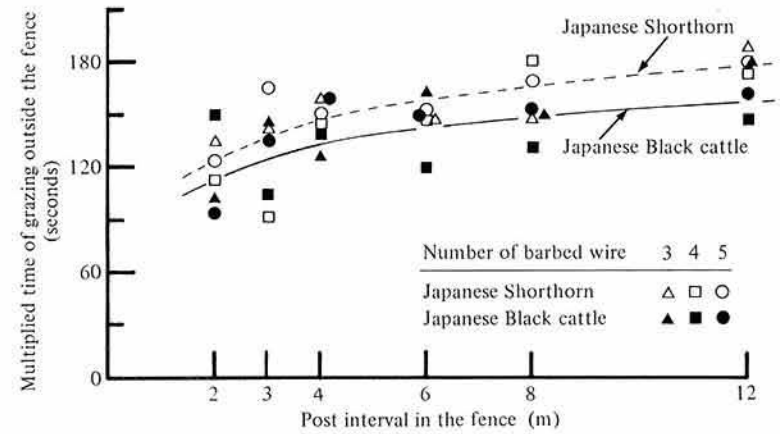

Fig. 2. Multiplied time or product of the frequency and the duration of grazing outside the fence for 180 sec per experiment

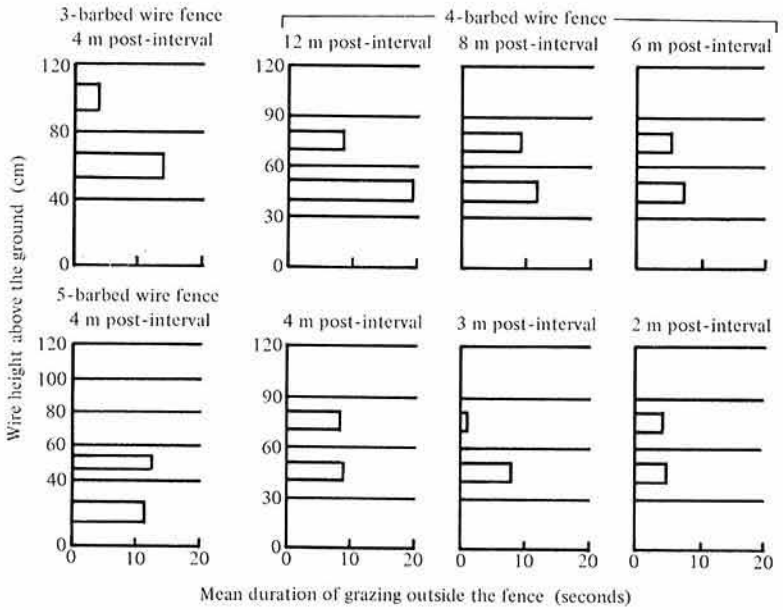

Fig. 3. Mean duration of grazing outside the fence per cow and per experiment (Japanese Shorthorn)

effective to make the wire spacing narrow, i.e. 30–80 cm which is 25–65% of the cattle withers height. Furthermore, Fig. 3 indicates that the maximum post interval is estimated to be 6 m from the observation of mean duration of the grazing outside the fence in 4-barbed wire fence.

When the cattle stick the heads out of fence into the wire space, the wire space became wider while the wire of fence was pushed, and then the wire tension was slackened. Fig. 4 shows that the wire tension was dropped under the wire space, where cattle grazed out of fence. It indicates that cattle prefer to stick the heads under the wire rather than over it, as reported by Hosokawa[5].

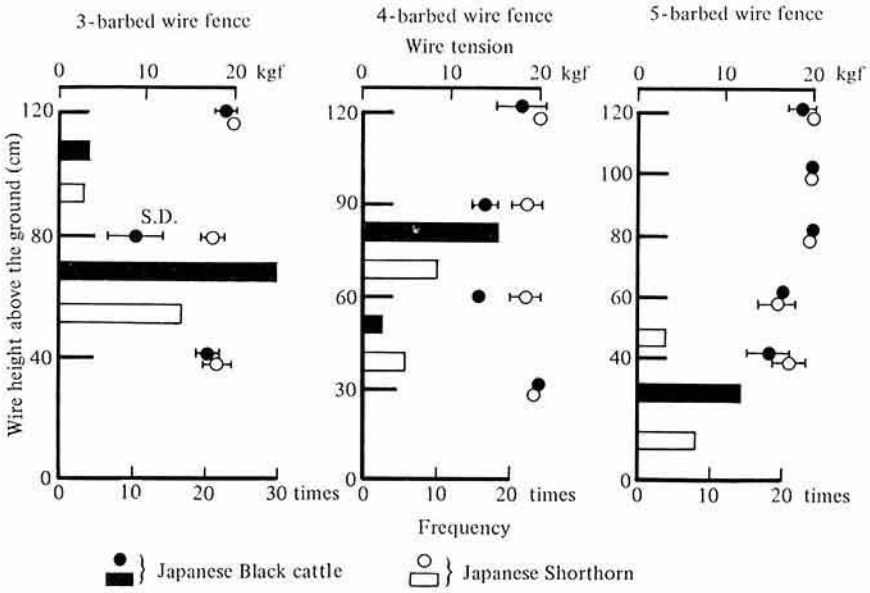

Fig. 4. Slackening of wire tension (●, ○) after the outside grazing at the initial wire tension of 20 kgf and total frequency (■, □) of grazing outside the fence under the condition of 4 m post-interval

Hosokawa reported also that the barbed wire was more effective to prevent the cattle from grazing outside the fence rather than the plain wire was as far as the wire tension was 25–50 kgf. However, no difference was found between 25 kgf and 50 kgf of the wire tension[5]. Further studies on wire tension are required.

The wire spacing is one of the functional components in preventing the cattle from grazing outside the fence. Taking into account the need for a strong structure of the fencing system with low costs, the experiment on wire spacing described hereafter employed a 4-barbed wire system rather than a 5-barbed wire system. The 4-barbed wire fence was installed in three kinds of post intervals; i.e. 4, 5 and 6 m. In each post interval, the following three kinds of wire heights were set up: a conventional type of barbed wire fence with wire heights of 30, 60, 90 and 120 cm above the ground; an experimental fence-type I with wire heights of 30, 55, 80 and 120 cm; and another experimental fence-type II with wire heights of 30, 50, 75 and 110 cm. The same cows of the above-stated experiment were used. Measurements of frequncy and duration of grazing were taken on each cow in each wire space. The concentrated feed was laid on a vinyl sheet as was done in the above experiment.

The frequency of cattle sticking into the wire space decreased as the posts were installed more narrowly. Less frequency also took place in the types I and II than in the conventional type. It is estimated from this result that a narrow wire spacing of 30–80 cm high above the ground would be practically effective to prevent the outside grazing. A less slackening of the wire tension took place as the sticking frequency decreased, especially in type II. Fig. 5 indicates mean duration of sticking into the wire space. The maximum mean duration of outside grazing per cow was about 20 sec under 30–80 cm wire height for Japanese Shorthorn, and about 10 sec under 50 cm or lower wire height for Japanese Black cattle. Type II of the fence with 4 m post-interval made the sticking duration shorter than the other types. As

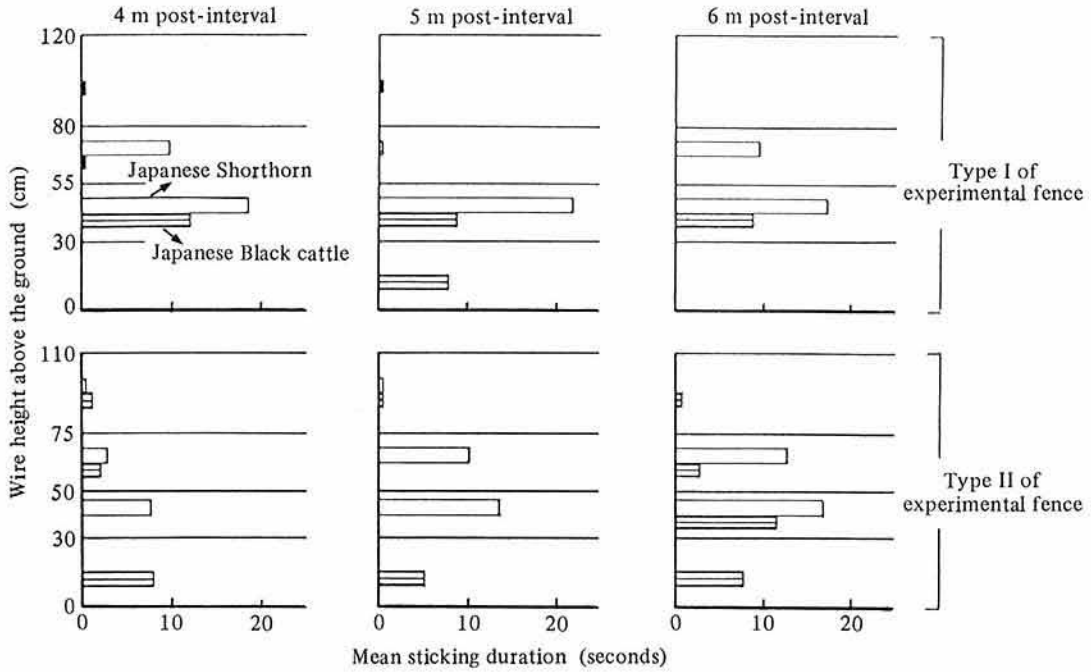

Fig. 5. Mean duration of being stuck in the wire space per cow
The total duration of grazing was 180 sec in each experiment.

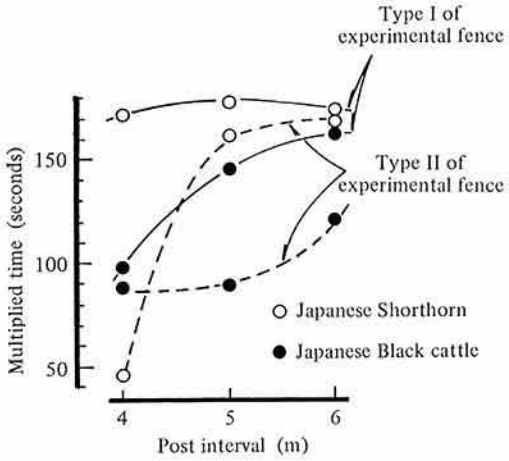

Fig. 6. Multiplied time of the frequency and the duration of cattle grazing in each wire space per cow
The total duration of grazing was 180 sec.

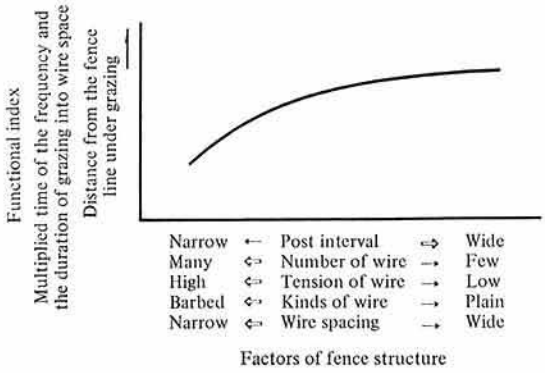

Fig. 7. Factors influencing fence structure and functional index to prevent the grazing outside the fence

shown in Fig. 6, the multiplied time of the outside grazing in each wire space was significantly shorter in type II, while no clear-cut difference existed in type I. It is therefore concluded that type II with 4 m post-interval is effective when the wire spacing is 30–80 cm above the ground. It is also concluded that the multiplied time is an appropriate index to measure effectiveness of the fencing systems for preventing the outside grazing.

In this experiment, the feed used was a concentrated stuff, the height of which above

the ground was not high as the grass sward was. Cattle graze the grass on pasture at about 5 cm high above the ground, thereby it is easy to distinguish grass with and without grazing. Therefore, it is possible to use the distance grazed from the fence line instead of the multiplied time, without counting the frequency and duration. In fact, counting the frequency and duration of sticking into each wire space was not an easy work during the experiment. Fig. 7 indicates the relationship between the factors of fence structure and the functional index to prevent the outside grazing.

Barbed wires for the fence: advantages and disadvantages

Barbed wires are widely used in the pastures of Japan. Fig. 8 indicates advantages and disadvantages of the barbed wire fence. It is necessary to take into account not only the cattle inside the barbed wire fence but also the workers who manage the fence as well as the function of the fencing system. It is a basic requirement to keep the wires rather tight in preventing the cattle from escaping.

The barbed wires, however, are very difficult to keep adequate tension under the undulate conditions of pastures in Japan, because the barbs prevent stretching the wires tight when the barbed wire fence is installed. In the snowy area, the barbed wires bear heavier snow than the plain wires due to their barbs. It is not rare that the barbs of wires are broken and fall down on the ground. Pieces of those broken barbs are off the guard by cattle during their grazing of grass beside the fence. Furthermore, the damages by rust at the non-galvanized sections of the barbs reduce the durability of the fence. From this point of view, the plain wires are more advantageous than the barbed wires for the fencing system particularly on undulate pastures. There is another advantage of the plain wires because the time requirement for constructing the fence is much smaller than the case with the barbed wires.

Function of the fence with high-tensile wires

Various types of plain wires in terms of diameters and zinc coating are available. The wires with a bigger diameter, however, are heavy in handling, while the wires with a smaller diameter are easily broken when stretched. In Japan, the wires of 2.6 mm diameter are generally used in agricultural

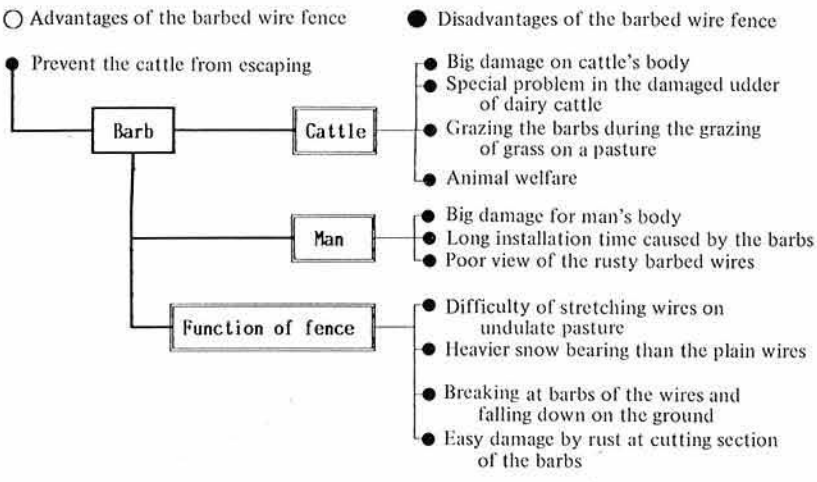

Fig. 8. Advantages and disadvantages of the barbed wire fence

facilities. Mild steel plain wires of 2.6 mm diameter are not strong enough, being affected by the change of temperature as well as by the thin zinc coating. On the other hand, high-tensile wires of 2.6 mm diameter, which have the breaking strain of 600–800 kgf with zinc coating over 250 g/m^2, are of more practical use for the fence.

An experiment was carried out to compare the function of barbed wires with high-tensile wires in preventing the cattle grazing outside the fence. In this study, the distance from the fence line under the outside grazing was used as a functional index, and the post interval and the kind and tension of the wires were used as factors relevant to fence structure. Four types of structure were compared as shown earlier in Table 1. Type A is a conventional barbed-wire fence, and type D is a high-tensile wire fence with droppers to keep the wire spacing at 2 m interval; in both types, wire heights were 30, 60, 90 and 120 cm above the ground. Three cows and three calves of Japanese Black cattle were used for grazing tests. The distance from the fence line under grazing was measured after grazing for 12 hr from 5 a.m. to 5 p.m. on the pasture of 189 m^2 with standing crop of 56 g/m^2 (dry matter). Mean distance was calculated so that the grazed area could be compared by post interval.

Table 2 shows mean distance grazed from the fence line. There was no significant difference among the fencing types. This result indicates that the high-tensile wires are the same with the barbed wires in terms of the function to prevent the outside grazing. In case of high-tensile wires, the wire tension of 80 kgf and the droppers interval of 2 m between each 4 m post-interval are required. Under this fencing system, there would be no cattle escaping and a complete prevention from the outside grazing beyond approximately 50 cm from the fence line would be assured. A wider post interval might be available, subject to the conditions of general management of cattle on the pasture.

Furthermore, droppers, which are important to keep the wire spacing without barbed wire and the wider post interval, are available to prevent the cattle from grazing outside the fence with a stronger wire tension. The strong wire tension is maintained by the use of high-tensile wire and wire-strainers in the fence on undulate pastures. A wider post interval with droppers contributes to reducing fence construction costs. The establishment of a fencing system on undulate pastures, with an adequate function and low construction costs to prevent the cattle from escaping would be practically feasible by using stronger corner-posts with wire-strainers, high-tensile wires and droppers.

Table 1. Structure of four types of the fences employed in the experiment

Type of fence	Post interval	Kind of wire	Tension of wire
A	4 m	Barbed wire	10 kgf
B	8 (4 m*)	Barbed wire	80
C	4	Barbed wire	80
D	8 (2 m*)	High-tensile wire	80

* Figures in parentheses indicate the interval of droppers between the posts.

Table 2. Mean distance grazed from the fence line after 12 hr grazing

Type of fence	Mean distance
A	47.3 cm*
B	40.2
C	45.2
D	51.4

* No significant difference among the mean distances.

Cattle behavior and fence disposition on sloping pasture

Domestic animals generally herd together. Beef cattle are apt to herd at the time of movement to drink water or resting to prevent the blood-sucking insect in summer time on pasture. Cattle often walk beside the fence[1,4,7] and occasionally escape from the fence during grazing, in case where the wires are broken or the posts fall down. It is observed that a herd of cattle sometimes

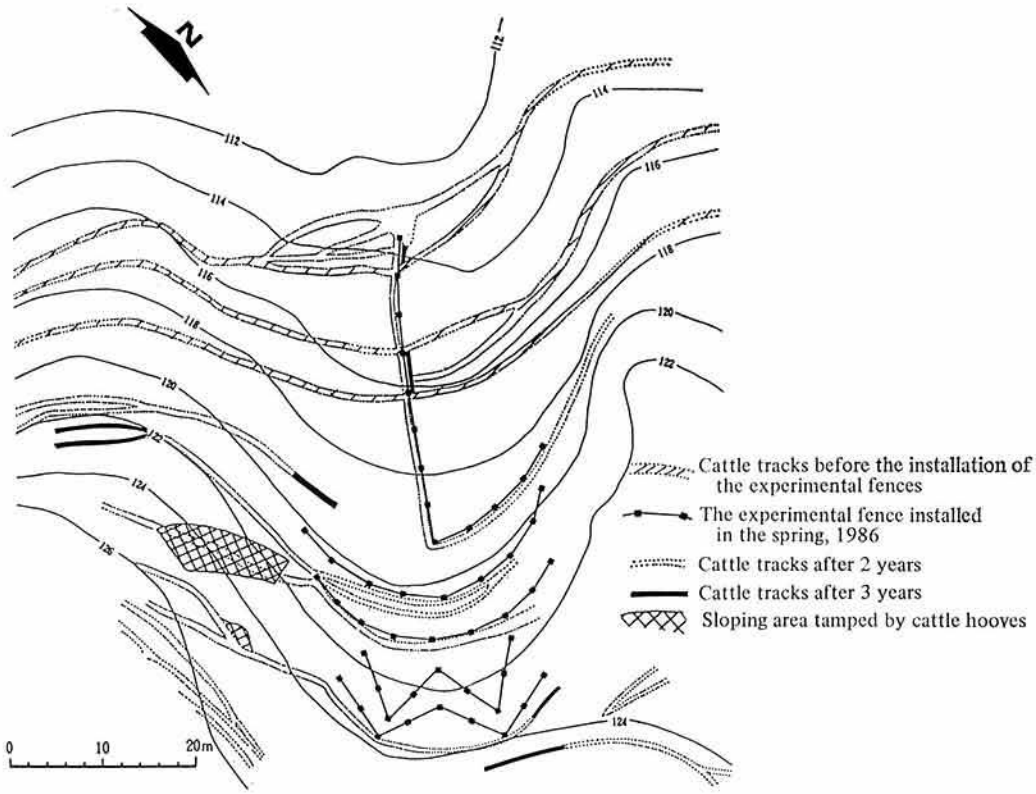

Fig. 9. Distribution of cattle tracks before and after the installation of the experimental fences

follows a cattle which intends at first to escape. Therefore, the fence should have the function to prevent the first cattle's escaping. On a sloping pasture, a water erosion takes place occasionally in the rainy season. One of the causes of the water erosion relates to the cattle tracks, such as small ditches or terraces formed by cattle, especially by a herd movement[6,7]. It is therefore necessary for designing a good fencing system to identify the effects of fence disposition on the cattle tracks on a sloping pasture.

In this study, experimental fences were installed on a sloping pasture, where only three cattle tracks had existed prior to grazing in parallel to the contour line. The inclination of the sloping pasture is 11–20 degrees. The distribution of the cattle tracks was surveyed two and three years later after the installation of the fence. The number of cattle tracks increased year by year as shown in Fig. 9. New cattle tracks were formed in parallel with the contour line between the upper and the lower fence line. The new tracks were also formed along the fence which was square with the contour line. The cattle walked freely to graze without walking on the tracks, moving to another pasture or the watering place while walking on the tracks after grazing. The water erosion took place in the tracks which were square with the contour line. These tracks became wider and deeper than the tracks parallel to the contour line.

Cattle track is a footprint of the cattle movement, which has to be carefully examined in connection with the erosion of sloping pasture land. The tracks formed in parallel with the contour line cause erosion to a

small extent. However, the fences installed in square with the contour line are certainly problematic because of the adverse effect of soil erosion on the grassland preservation. A herd of cattle occasionally makes tracks on the ridge of pasture. Therefore, the fence disposition on the sloping pasture has to be designed so that the longer side of a rectangle form of the paddock is installed along the contour line and the shorter side of the paddock is not too close to the ridge.

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