Characteristics of Cattle Tracks on Steep Grassland in Relation to Cattel Behavior and Land Conservation

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Introduction

On steep grassland, narrow strips of naked land, which are called cattle tracks, occurring by repeated treading of cattle are distinctly recognized. This treading path is a locus showing the customary grazing behavior, and can be used as a source of a lot of information regarding cattle movement on steep grassland[1].

On steep grassland, it is necessary to maintain the function of animal production together with that of land conservation for many years[2,3]. It has been considered that the cattle track has close relationship to erosion and destruction of grassland. However, problems such as characteristics of the cattle track and its relation to grazing behavior and to land conservation have not almost been made clear[1,4,8].

Therefore, from the viewpoint of land conservation, the present authors[5,6] have attempted to clarify quantitatively the characteristics of the cattle track, and the method to control it on the basis of its characteristics, for the improvement of the grassland management method, by paying attention to the ocurrence and development of the cattle track.

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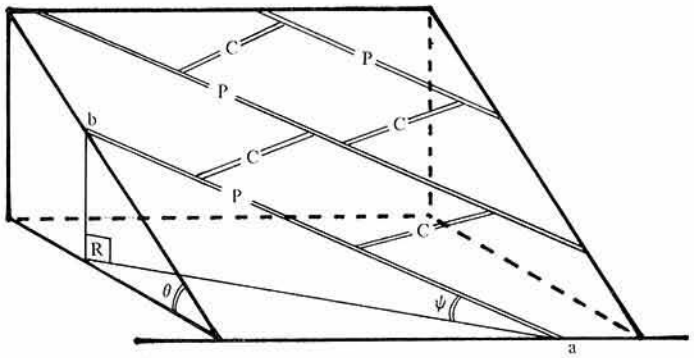
Materials and methods

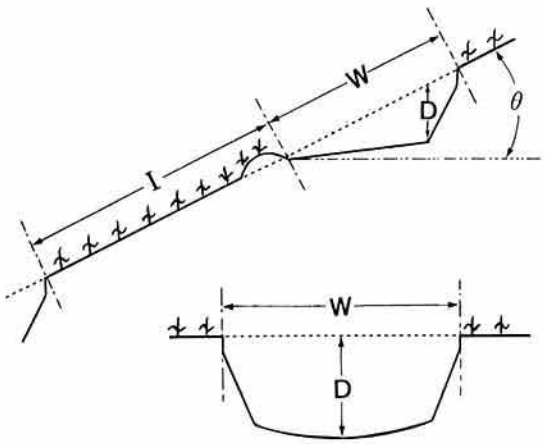
The survey was carried out for seven years, starting from 1971 on the grassland (ca. 19 ha with a 5–40 degree inclination) which was established by no-till direct seeding in 1966–1970 on the Black volcanic ash soil slopeland in the Alpine Region Branch of the National Grassland Research Institute. On this grassland, rotational grazing with the interval of 20–30 days was practiced at the grazing intensity of 500–600 AU of raising cattle during a period of 180–210 days, starting from April, every year. The dominant grass was *Dactylis glomerata* L. mixed sown with several other species.

The characteristics of the cattle track were examined by actual measurement on the spot and the aerial ortho-photograph (scale: 1/25000) with contour lines for every 2 m. The movement of cattle was observed every 1–5 min from an observation tower. Angles of inclination were measured using hand levels. In Fig. 1, θ indicates the maximum inclination of a slope, and ψ the ascending/descending inclination of a cattle track (inclination between a and b). The average angle of a slope was measured as follows: a 5 mm mesh (5 mm corresponds actual length of 12.5 m) was placed over the ortho-photograph and the average angle of a slope was calculated from the height above sea level of its four corners. Width and depth of cattle tracks were obtained by measuring W and D



θ : The inclination of the slope
R : A right angle
ψ : An angle of cattle tracks against the water level (inclination of tracks)
P and C : Parallel and conjunctive cattle tracks

Fig. 1. A schematic figure of cattle tracks in steep grassland



----- : The original ground surface
——— : The present surface
W : The width of cattle track
D : The depth of cattle track
—·—· : The water level
θ : The inclination of the slope
I : The interval between cattle tracks for grazing

Fig. 2. A schematic figure of the transection of a horizontal cattle track (upper) and a vertical cattle track (lower)
The transection of a horizontal cattle track generally shows triangular or bow-shape, and that of vertical one always shows the shape of the bottom of a ship.

in Fig. 2. Cattle track density was the numbers of cattle tracks found in the above-mentioned mesh and its relation to grazing facilities and topography was estimated. Surface runoff and soil erosion occurring on cattle tracks were measured by placing a frame (3 × 10 m) on a slope on which cattle tracks are markedly developed, and giving artificial rain from the sprinkler[6].

Results and discussion

1) Classification of cattle tracks and the use of cattle tracks by herds

A large number of cattle tracks developed on grassland were classified into seven types on the basis of topography and features of areas on which the cattle track developed, and outer appearance of the cattle track (Table 1)[5].

Type 1. Parallel cattle track: Many cattle tracks run as parallel lines nearly along contour lines on a widely opened steep slope. Herds utilize these tracks to move and to graze.

Type 2. Conjunctive cattle track: It serves to connect parallel tracks. Herds in grazing move to higher tracks or lower tracks through the conjunctive track. Type 1 tracks and type 2 tracks intersect, making the network path on the slope.

Type 3. Bee-line cattle track: From the place, where cattle can directly see water and salt supply facilities, to the site of the facili-

Table 1. Seven types of cattle tracks developed on steep grassland and their characteristics

Types	Relation to behavior of cattle herds			Inclination (ψ) of cattle tracks		
	C. t. for grazing	C. t. for migrating		Horizontal	Slantwise	Vertical
		Purposive type	Restricted type			
1. Parallel c. t.	●			●		
2. Conjunctive c. t.	●				●	
3. Bee-line c. t.		●		○		●
4. Trans-landslide c. t.		●			●	
5. Para-fence c. t.			●	○	○	●
6. Peri-bush c. t.			●		○	●
7. Circular arc c. t.	○	○	○	○	○	

Note: Relation to behavior of cattle herds; ● Strong relation, ○ Weak relation.
Inclination of cattle tracks; ● Almost, ○ Slightly.
C. t.: Cattle track.

ties, a straight cattle track is developed. Cattle make a bee-line for the facilities through this cattle track.

Type 4. Trans-landslide cattle track: The cattle track developed on waste land without vegetation remaining after landslide which occurred by cattle movement at the steep slope more than about 40 deg. Herds use this track when they move to grassland located above or below the landslide area.

Type 5. Para-fence cattle track, and Type 6. Peri-bush cattle track: When cattle encounter the fence or the bush they make a detour along the fence or the bush. The cattle tracks thus developed are types 5 and 6.

Type 7. Circular arc cattle track: This track runs along the contour line, drawing an arc at the valley bottom. Herds pass through this track to migrate to grassland on the other side of the valley.

These cattle tracks are also classified into three groups according to different patterns of utilization by cattle:

group 1; cattle tracks for grazing: Types 1 and 2,

group 2; cattle tracks for purposive migrating: Types 3 and 4, and

group 3; cattle tracks for restricted migration: Types 5 and 6.

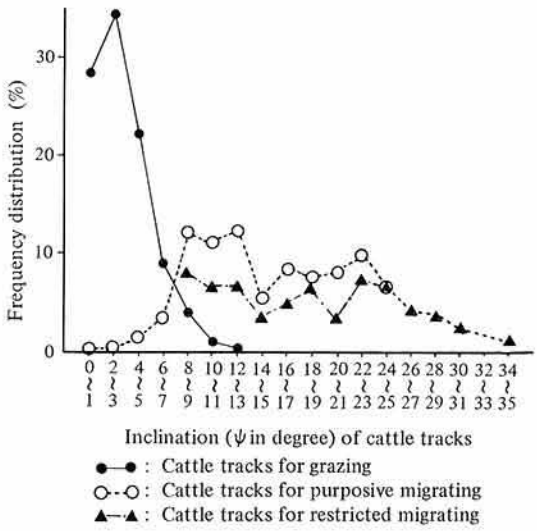


Fig. 3. Frequency distribution of the inclination of cattle tracks

2) Ascending/descending angles of each group of cattle tracks

Different groups of cattle tracks showed different relations between the ascending/descending angle (ψ) and the inclination of the slope. As shown in Fig. 3, the value of ψ of parallel tracks was 8 deg at the maximum and 3.3 deg in average, showing that they are almost horizontal. The conjunctive tracks showed 12 deg at the highest and 4.5 deg on

the average of ψ, so that they are slightly steeper than the parallel cattle tracks. These tracks for grazing occur always on the slope steeper than 13 deg, but their ψ values are not almost related to the inclination of grassland.

The cattle tracks of the group 2 were steeper than tracks for grazing. The bee-line track occurs almost on the maximum inclination line of the slope, so that its ψ is equal to the inclination of the slope, showing ψ value of 25 deg at the highest, and 17.0 deg on the average. The trans-landslide track showed 10–11 deg with 10.4 deg on the average of ψ, irrespective of the slope inclination.

On the other hand, ψ of the group 3 cattle track depends on the obstacles, showing 35 (maximum) and 17.0 (average) deg.

From these ψ values, it is considered that grazing cattle want to move horizontally as far as possible in free walking, while they ascend or descend up to about 25 deg of ψ in case of moving with purpose, and up to about 35 deg in restricted migration.

Furthermore, these cattle tracks were divided into two groups based on ψ and direction of the track: 1) horizontal one developed in parallel to the contour lines with small ψ and 2) vertical one developed along the direction of runoff with large ψ.

3) *The width and depth of cattle tracks*

The width and depth of cattle tracks for grazing were different from those of the other groups of cattle tracks, i.e., the width of parallel cattle tracks was 34 cm, while that of all other tracks was greater than 40 cm, except conjunctive tracks which was the narrowest, showing 33 cm. On the other hand, the tracks for grazing were shallow (ca. 11 cm in depth), but other types were deep (14–17 cm). The width and depth of cattle tracks tend to increase with the increase of inclination of slopes. A positive correlation, r=0.856, was observed between the width and depth of cattle tracks.

The development of cattle tracks on sloping grassland varies with different species of

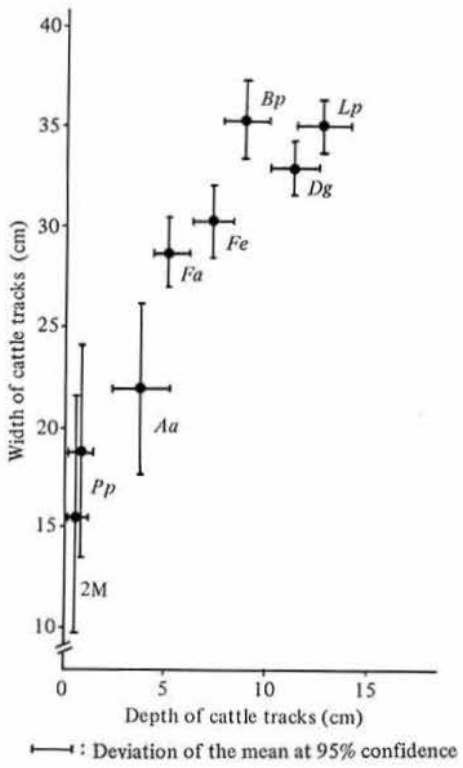


Fig. 4. Relationship between the depth and the width of cattle tracks
Bp: *Bromus pauciflorus* Hack,
Lp: *Lolium perenne* L.
Dg: *Dactylis glomerata* L.,
Fe: *Festuca elatior* L.
Fa: *Festuca arundinacea* Schreb.,
Aa: *Agrostis alba* L.
Pp: *Poa pratensis* L.,
2M: *Pp*+*Trifolium repense* L.

dominant grass of the grassland. Therefore, the width and depth of the tracks for grazing were examined in relation to grass species. The result given in Fig. 4 indicates that tall and bunch type grasses without rhizome or stolon (*Lolium perenne* L., *Dactylis glomerata* L. and *Bromus pauciflorus* Hack) induce wider and deeper tracks, while short grasses with rhizome or stolon (*Agrostis alba* L., *Poa pratensis* L., and *Poa pratensis* L. + *Trifolium repense* L.) allow narrow and shallow tracks. In other words, the latter group is resistant to the development of cattle tracks, while the former group is least resistant. Tall and bunch type grasses with rhizome (*Festuca*

arundinacea Schreb and *Festuca elatior* L.) are just intermediate between the two groups. In view of preventing the enlargement of cattle tracks, i.e., enlargement of naked land on steep grassland, it seems desirable to grow short grasses with rhizome or stolon, whihc are called sod-formers.

4) Relation of cattle tracks to the land conservation

The density of the cattle tracks for grazing was low on gently sloped grassland, but it increased with the increase of inclination to the level not to be neglected. The change of the distance between the tracks (shown as I in Fig. 2) is expressed as $I=24.50\,\theta^{-0.834}$, where θ is an inclination angle. The area of naked land in percentage to the total land area was calculated using the above equation. It was 17, 22, and 25% for 18, 22.5, and 28 deg of θ, respectively. The naked area increases in proportion to θ.

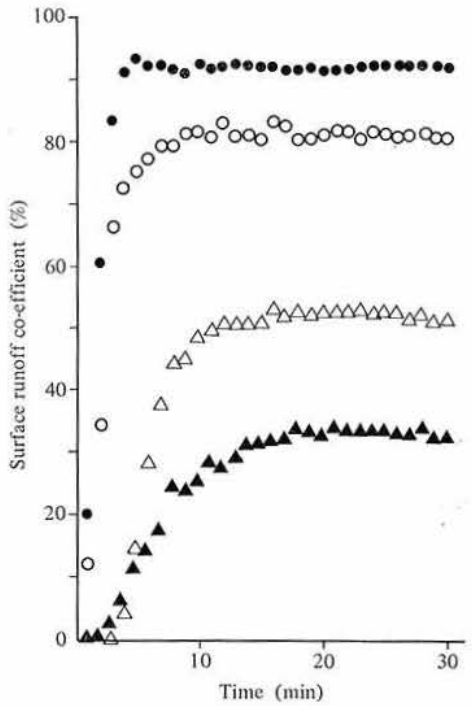


Fig. 5. Changes of surface runoff coefficient with time after the start of artificial rainfall
○, ●: Vertical cattle track with 10 and 18 deg of ψ.
△, ▲: Horizontal cattle track with 25 deg of ψ, under the condition of grass mowed and grass standing.

The density of cattle tracks was high in the area near grazing facilities and near the bottom of valley. The proportion of each type of tracks was as follows: tracks for grazing; ca. 70%, bee-line tracks; ca. 15%, trans-landslide tracks; ca. 1.5%, para-fence tracks; ca. 11%, and peri-bush tracks; ca. 3%.

Among the cattle tracks developed on sloped grassland, the tracks for grazing, which are horizontal, hardly showed water erosion, but other vertical tracks, such as the bee-line track, trans-landslide track, para-fence track etc. showed a lot of water erosion. Then, the amount of surface runoff and erosion was measured on horizontal tracks and vertical tracks (Fig. 5). The surface runoff coefficient measured on vertical tracks 5 min after the beginning of rainfall was 75% in case of 10 deg of inclination and more than 90% at 18 deg of inclination. On the contrary, that measured on horizontal tracks was only 30–50% even at 30 min after the beginning of rainfall. The amount of soil loss caused by runoff on vertical tracks was 3.1 t/ha·hr, which was about 16 times that on horizontal tracks. It was considered that vertical tracks pose a great problem to land conservation[6].

Conclusion

On steep grassland, a lot of cattle tracks specialized for grazing alone are developed, and the land area occupied by them is not small. But, they are nearly horizontal, so that their influence on land conservation is small. The rainfall intensity which causes surface run-off was calculated for the horizontal and the vertical cattle tracks. On the vertical track the rainfall intensity of 20 mm/hr caused 10–30% runoff, while on the horizontal track it was estimated that no runoff occurs at the intensity lower than 50 mm/hr. As a matter of fact, water erosion was hardly observed on horizontal tracks. Therefore, for

the purpose of land conservation of steep grassland, control of vertical tracks is needed.

As already mentioned, vertical tracks occur along artificial facilities (such as fences, water-suppliers or salt-suppliers) and bushes. The site of their occurrence can be foreseen based on topography[3]. Therefore, by adopting such methods to grassland management as sowing grass species highly tolerant to cattle treading[2] or setting up fences to divert the course of cattle tracks, the land conservative function of the steep grassland can considerably be increased.

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