THE INFLUENCE OF TREADING ON PASTURE

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In 1858 H. S. Thompson, writing in the "Journal of the Royal Agricultural Society", quoted an ancient Persian proverb, "The sheep has a foot of gold, and turns to gold whatever it touches", and wrote that, although at first he agreed with the proverb, he rapidly became dissatisfied with it. In his experience-sustained heavy stocking with sheep caused pastures to deteriorate. In my opinion his impression was that the sheep's "foot of gold" was a complex influence with benefits accruing from returned dung and urine and penalties imposed by untimely defoliation which necessarily entailed treading. He believed that it was important to use young cattle on establishing pastures "until the turf is close and strong enough to bear the treading of heavy cattle." In 1873 he reaffirmed his opinions with an amendment that carefully managed sheep should be the first on pastures intended for cattle grazing. His opinions, in the main, agree very well with modern ideas. A local opinion has been that for vigorous growth of perennial ryegrass, plants must be continually pushed into the soil, which must be compressed around them. Accordingly, hoof cultivation has been of wide popularity; it is not uncommon to be told that a good pasture should be "blackened" once a year.

A number of workers, notably Bates (1930, 1935, 195 1), Chandler (1940), Crocker (1953), Klecka (1937), Lieth (I 954), and Steinbrenner (195 1 j, have observed the influence of treading on pasture and are unanimously of the opinion that it damages plants. Levy (1926) exploited this fact by using cattle to tread out susceptible weeds from North Island hill country pastures, while Packard (1957) has introduced another point of view by suggesting that compaction by treading improves light pumice soils for plant growth.

Our farming systems entail relatively high stocking rates and year-round grazing, which mean that treading must be important. In the winter on most farms poached pastures are clear evidence for this importance, as, at all times of the year, are pathways, gateways, and races where susceptible plants have been progressively eliminated until the soil becomes bare.

Sensibly, treading should be studied as such, for as Thompson realised, it can be a problem distinct from the influences of defoliation and excretion. Its effects can be direct and indirect to both plant and soil, which implies that short-term effects must be distinguished from long-term effects. As fertility considerations are less troublesome in short-term trials, it was decided at Grasslands to study first the short-term influence of treading.

A New Approach

From a suggestion by E. 0. C. Hyde, a technique was evolved and is under test at Grasslands Division (Edmond, 1957). In summary, narrow fenced plots are used, up and down which sheep are driven a specified number of times. By removing all herbage before treading and by keeping the sheep walking during treatment, defoliation is kept at a minimum, while excretion is reduced by underfeeding them for some hours before treading.

The technique is not completely satisfactory. For instance, sheep driven along the plots appear to walk quite differently from sheep idling on a pasture, and mobbed sheep tend to straggle so that, despite care, the centre of each plot is trodden more than the sides. By and large, the treatments have been like a special kind of mob stocking which it is impossible to define absolutely. Recent data (Cresswell, 1957) suggest that the treading rates used might have been 50 to 60 per cent. in excess of the supposed rate; that is, 4 sheep set-stock equivalent per acre, as applied, might have been 6 sheep. However, the fact remains that treading is by far the greatest influence in the technique, and as such it can be studied.

Investigations Completed

1. Using the technique, the treading of 0, 4, 8, 12, 16, and 20 sheep set-stock equivalent per acre was imitated in the winter of 1956 on a short-rotation ryegrass-clover pasture with high initial fertility and good soil structure. Treadings were applied with the soil at about field capacity, approximately 40 per cent. for the top 3in. The results are summarised in Fig. 1, which was constructed from dry weight yield of herbage data secured 30 days after one treading of the uniform pasture.

Experimental treading at the heaviest rate (20 sheep set-stock equivalent per acre) reduced dry weight yield of herbage by about 60 per cent., while the lightest rate (4 sheep set-stock equivalent per acre) reduced it by 10 to 20 per cent. In this investigation white clover (*Trifolium repens*), *Poa annua, Poa*

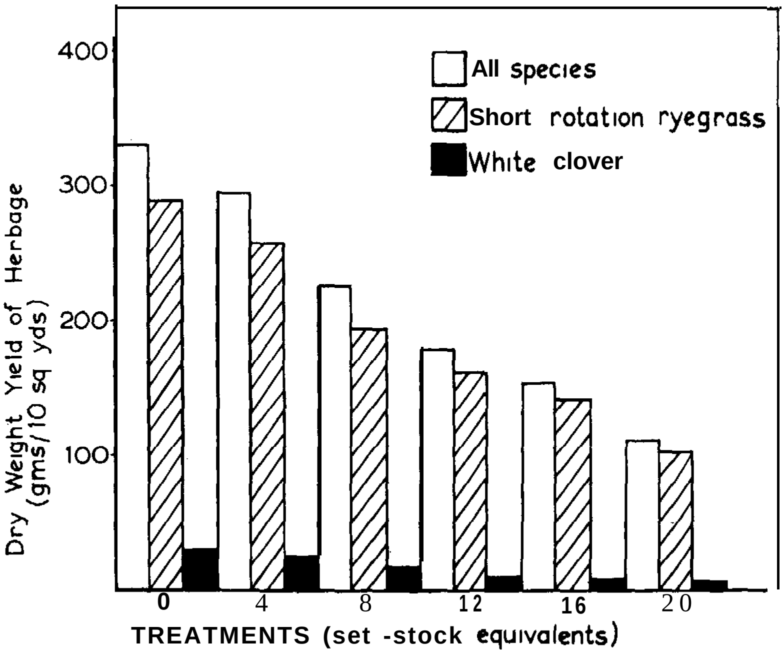

Fig. I.

trivialis, and *Cerastium glomeratum* were more susceptible to treading than short-rotation ryegrass. Because of these species differences in suceptibility, the long-term effects of treading included marked changes in botanical composition. Generally, however, the main effects of the first treading in terms of damaged plants and changed soil were repeated with little change at succeeding treadings. Perhaps some of the intensification of effect which did occur could have been attributed to changes in soil condition, for the soil was more dense under heavy treading, and gleying, typically indicative of oxygen deficiency, appeared in the dense layer.

Clearly, treading did influence pasture, by damaging it. Perhaps in exceptional cases of dry, loose soil and drought-resistant, treading-tolerant plants a pasture might be trodden with immediate beneficial results, but it seems more likely that treading will cause direct damage.

It is also clear that increased rates of treading caused increased damage. It was thought possible that it might be relatively more severe at some particular treading rate. However, regression analyses proved that there was a linear relationship between treading rate and dry weight yield of herbage. Thus the only critical treading rate could have been that at which the pasture would have been obliterated. The point is of academic interest, **but** calculations using the data available suggest that this value was the 27 to 32 sheep rate.

2. Cattle and sheep grazing were compared during the period July to October 1955, using a new short-rotation ryegrass-clover pasture. Stock were grazed for the shortest time possible until the pasture was closely and evenly defoliated. Herbage yield measurements were made using the well-known cage technique (Sears, 1951).

The only clear difference between the grazing treatments was the presence of pronounced soil gleying to 4 to 6in. depth under cattle grazing, but it should be noted that sheep grazing usually took longer to complete.

At the first grazing the cattle were introduced to one replicate while there was free water lying in pools on the surface. Within half an hour the surface soil was badly puddled and pasture vigour appeared to be reduced within a few days. Water lay on the surface for weeks after the treading, and soil gleying became pronounced.

At the next harvest the difference in herbage production between this replicate and the others was significant at the 10 per cent. level, and the effect was observed to persist until the end of the investigation.

It is of interest here to recall that in the first investigation, where strongly developed gleying could be seen, the surface soil had *also* been puddled.

Thus the evidence indicated that puddling of the surface soil might reduce pasture vigour markedly and that puddling was most easily effected when water lay in pools on the surface.

3. Using the plot treading technique, the treading of 0, 6, and 12 sheep set-stock equivalent per acre was imitated in the summer 1956-57 on a short-rotation ryegrass-clover pasture, with reasonably high initial fertility, weakly developed soil structure, and at three levels of soil moisture (Edrnond, 1957). The moisture levels, which were dry, moist, and wet (free surface water), were created using spray irrigation.

Table 1 summarises the influence, after 30 days, of the first treading of the uniform sward.

It can be seen that treading reduced herbage yield irrespective of soil condition, short-rotation ryegrass being particularly susceptible. With repeated treadings short-rotation ryegrass was greatly reduced. Vigorous clover growth and declining soil fertility clouded the issue, but it did appear that treading was particularly damaging in wet soil conditions. Certainly the greatest reductions in yield occurred under the heaviest treading.

Although the surface soils of the plots under the wet treatments were puddled, there was no evidence of gleying. This might be explained by the repeated cracking of the soil due to alternate wetting and drying, which no doubt reduced the puddling effect.

Subsequently it was found that worm activity was reduced in heavily trodden plots, and this could have been due to a reduced food supply (Waters, 1955).

It is important that pasture trodden under dry soil conditions was reduced in vigour.

Table l-Relative Dry Weight Yield of Herbage After One and Three Treadings of Uniform Pasture (Summer 1956-57).

	One Treading		Three Treadings
	All Species	Short-Rotation Ryegrass	Short-Rotation Ryegrass
Control	100	87	100
Dry soil 6 sheep	84	100	69
Dry soil 12 sheep	85	97	68
Moist soil 6 sheep	74	64	30
Moist soil 12 sheep	80	43	32
Wet soil 6 sheep	78	66	32
Wet soil 12 sheep	65	49	17
Sig. diff. at 1% level	—	37	—
Sig. diff. at 5% level	17	—	—
Sig. diff. at 10% level		—	46

General Results and Discussion

Another consideration was plant density, which varied from treading to harvest, yet at harvest there was little variation from treatment to treatment. Exceptions were short-rotation ryegrass in the summer and both white clover and *Poa* spp. in the winter and spring. Immediately after treading, particularly under heavy treading in moist soil conditions, plant density was reduced. The survivors, being relatively free from competition, developed new tillers rapidly until density was approximately the same in all treatments. As species were more or less common to all treatments, this equilibrium density would have been largely determined by the dominant component of the environment, which at first sight appears likely to have been the quantity of light energy incident on the plots. This equilibrium density appeared to be reached within two weeks in the spring.

As it is, the reduced yields of damaged plots can be explained by lowered mean daily plant density and by the relative immaturity of the plants present at harvest time.

No explanation is offered for the failure of short-rotation rye-grass in the summer situation or for white clover in the winter, but it is possible that dormant plants may be relatively susceptible to treading damage, particularly in the presence of competition.

Effects of treading on the soil appeared to consist of compaction of the surface layers with reductions of large pores, and destruction of aggregates with obliteration even of fine pores. This occurred most easily when the soil was moist. When the soil was wet destruction of aggregates was excessive and a slurry was formed which was only about as dense as normal soil (Gradwell, 1956). The gleying, which occurred where the fine pores had been obliterated, together with increased density, no doubt affected plant growth. Probably the type of structure imparted to the soil in the summer by alternate wetting and drying prevented gleying in the third investigation.

Usually within 2 or 3 weeks worm activity, plant growth, and drying appeared to have restored a semblance of structure to the surface soils of the most severely damaged plots. The degree of improvement needed to benefit plant growth is not known, but it is plain that an extended spell, implying marked improvement in soil structure, must be beneficial.

Clearly, treading can cause large and persistent reductions in pasture vigour.

Practical Considerations

1. Perhaps periodical treading damage can be tolerated if weeds are reduced as a result and it may be that "blackening" leads to improved pasture growth, but any benefits accruing must be balanced against losses. Both weed control and improved pasture growth might better be achieved by effective but less damaging methods.

2. As wet soils are particularly unstable, care should be taken to restrict treading damage in such conditions. In this respect June-July may be important, for in Palmerston North at this time mean net daily loss of water by evaporation from a free water surface has dropped from the January figure of 0.16in. per day to about 0.03in. per day. At this time, and as a result of earlier wetting of the soil, pools of water can lie on the surface.

3. In these investigations shallow, dense soil layers did not, in themselves, appear to impede plant growth, but when gleying also occurred it was reduced. However, there are instances in Taranaki and south Auckland where treading appears to have produced soil pans which on their own interfere with normal plant growth. Clearly, the influence of treading must vary from

one soil type to another, and farmers must be watchful for its particular effects on their own farms.

Conclusion

The work reported here has been done under short-term experimental conditions on one pasture type and on one soil type. Treading damaged all pasture plants immediately, but some species were affected more than others, so that in the recovery growth botanical composition was changed. In high production pasture, where balance between species is important and where treading is heavy, this could have a marked depressing effect on pasture production, particularly where plants such as white clover are reduced to a low density.

Further, and underlying the whole, is the effect the soil has on plants when it is modified by treading, and it seems likely that this is important.

Recovery of plant and soil follows treading damage, but the ways in which it happens are not yet understood. As a result it is not possible to predict degree of damage and persistence of its effects for any particular situation. When this work has proceeded further and when the appropriate animal behaviour studies have been advanced, information should become available which will enable us to assess our farming systems in a better light.

In the meantime and if pasture production is to be kept at the maximum possible, it may be concluded that every effort should be made to prevent unnecessary treading at all times, but particularly when the soil is wet.

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DISCUSSION

Q. In these trials were investigations carried out at different pH levels.
A. No work has been done with regard to pH levels but I doubt whether the use of sulphate of ammonia on a wide scale would be either economic or desirable.
Q. Can Mr Edmond give any information of the relative distribution of macro and micro pores of different soils as affected by treading.
A. No.
Q. Would the effect of treading on defoliated pasture differ from that on undefoliated pasture and also have a differential effect on various species.
A. Mr O'Connor has done work on short and long pasture and found that treading damage was less on long pasture.
Q. Is Mr Edmond going to pursue this work on types of pasture other than short rotation ryegrass-clover swards.
A. Plots are being established with 10 different species to find out what are susceptible species or which species may stand up to treading.
Mr Slater (Comment). In my experience with increasing fertility and increase of worm populations, treading damage becomes more acute with increase of fertility and a rise in pH to 6.8. I practise short bursts of mob stocking with spelling to overcome this treading damage.
Prof. Hudson (Comment). At Massey College an area of Tokomaru silt loam has been under fertiliser treatments for 17-18 years. One series has had no added lime and has a pH of 5.6. Another series limed has a pH 6.2-6.5. When wet in winter and spring the limed series pugged more than the unlimed. The production from limed series was greater than from the unlimed series with a resultant build up of organic matter.

Organic matter is an important factor on water retention.