THE PROVENANCE OF GIZZARD GRIT FROM THE RED GROUSE *(LAGOPUS LAGOPUS SCOTICUS* (LATH.)) OF BLEAKLOW, DERBYSHIRE

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Introduction

Five million acres of moorland in the British Isles are specifically managed to provide optimum conditions for the Red Grouse, *Lagopus lagopus scoticus* (Lath.), to flourish as a popular game-bird. Grouse moors are characterised by an abundance of Ling heather, *Calluna vulgaris*, which is burnt in strips on a rotational basis to give a mixture of young heather for food and older plants for shelter. Although *Calluna* is the main diet of the grouse, at certain times of the year other foods may be taken, such as *Vaccinium* spp. (Yalden, 1972), *Erica cinerea*, *E. tetralix*, *Arctostaphylos*, *Empetrum* and *Eriophorum* (Bannerman, 1963) and insects, especially craneflies (Diptera, tipulidae) (Butterfield and Coulson, 1975). Most of these foods are tough and fibrous, so particles of grit are actively ingested and kept in the muscular gizzard to grind up food and thus aid digestion. Sturkie (1965) gives a summary of research done on the importance of grit in digestion in poultry. To obtain supplies of grit the grouse make regular expeditions to the bottoms of cloughs and hill roads, and when the moor is snow-covered flocks may travel over a mile to obtain grit. As part of the general management of grouse moors, most game-keepers supplement the natural grit supply with artificial grit. This is put down in small piles of a few handfuls each. It is the purpose of this study to find the source of the gizzard grit from birds shot on a managed moor, and to determine whether the supplementary grit had been utilised by the grouse in preference to natural grit which is readily obtainable on the moor.

The Committee of Inquiry on Grouse Disease made a comprehensive study of the Red Grouse and their final report appeared in 1911. As a contribution to this report, Smith and Rastall (1911) researched into the gritting habits of grouse. One experiment involved depriving a captive grouse of grit and subsequently the bird died. This led to concern over the adequacy of natural grit supplies and to the introduction of grit supplementation on grouse moors.

Methods and Results

The area studied is a grouse moor of about 0.5 sq. km. on the north-east side of Bleaklow, Derbyshire (fig. 1). The solid geology is Millstone Grit (Upper Carboniferous, Namurian), overlain by peat supporting a typical moorland flora with *Calluna vulgaris* dominant. Sixteen gizzards were obtained from grouse shot early in the 1974 season, but no record was available of the birds' ages or sexes. Samples of moor grit (grit occurring naturally on the moor and grit supplement put down by the gamekeeper) were collected. Descriptions of these, together with the sample numbers, are provided in table 1. When opened, the gizzards were found to contain leaves and tops of *Calluna*, a few seeds of *Vaccinium* and other plants, and numerous particles of grit.

Size Range

The grit was hand-sieved using BS 410 sieves. Ninety-eight per cent of the total gizzard grit was retained on meshes 6 to 14. These particles are the ones which the grouse actively select. Depending on the size, age and sex of each bird (Kolderup, 1923) there is an upper limit above which the particles are too large to be swallowed. Below about 1.22 mm. the particles

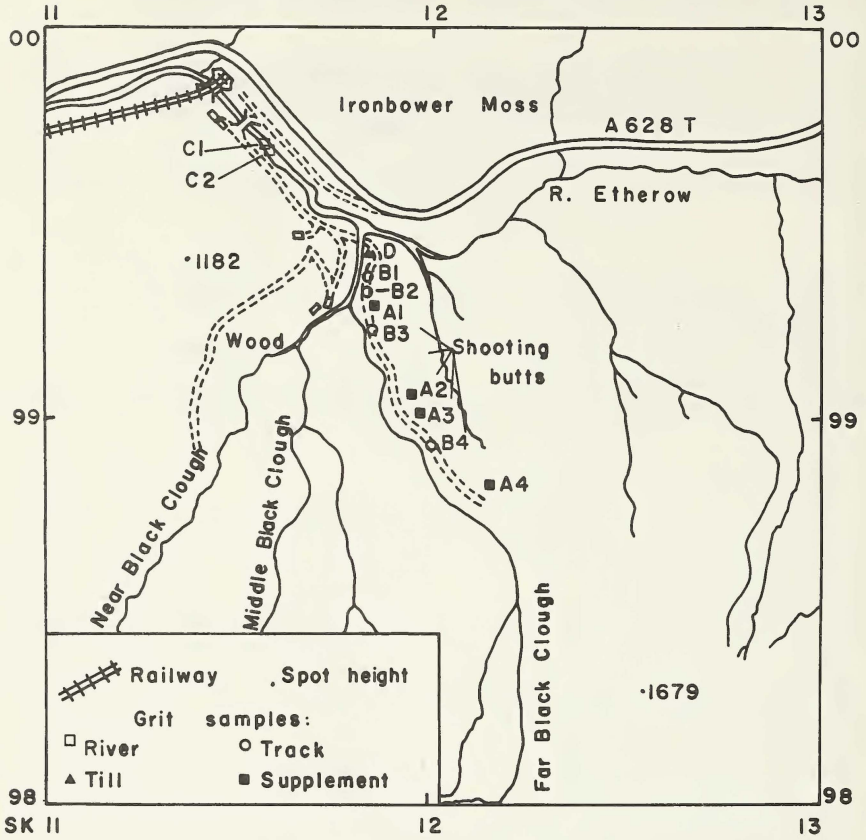

Figure 1. Location map.

No.	Description	Grid Ref.
A1	Grit supplement, dispersed on peat.	117993
A2	Grit supplement.	119990
A3	Grit supplement.	119990
A4	Grit supplement, grouse droppings nearby.	121987
B1	Track grit.	117995
B2	Track grit, grouse droppings nearby.	117994
B3	Bleached grains washed from peat beside track.	118992
B4	Track grit.	119989
C1	Grit from shoal in River Etherow.	115997
C2	Grit from shoal in River Etherow.	115997
D	Till.	117996

Table 1. Numbers and descriptions of grit samples.

are small enough to have been ingested accidentally with food and larger grit particles, as suggested by Smith and Rastall (1911). A chi-squared test was performed on the optimum size range, taking the mean percentages of all the gizzard grit together as the expected percentage and the moor grit samples separately as observed percentages. The size frequency curves are shown in fig. 2, and the results of the chi-squared tests in table 2.

The gizzard grit shows a fairly symmetrical distribution about a mean diameter of 1.77 mm. The grit supplement (samples A1 — A4) differs markedly from this in being positively skewed, that is, the grains are generally larger than those of the gizzard grit. The chi-squared test shows that none of the grit supplement samples have any similarity to the gizzard grit size distribution. Three of the track grit curves (samples B1, B2 and B4) follow the gizzard grit curve quite closely, but sample B3 contains more large grains. Of the river grit samples (C1 and C2), one (C2) is quite close to the gizzard grit mean curve, but C1 differs from it greatly. The curve for till (sample D) is platykurtic, thus the chi-squared test shows it to differ from the gizzard grit distribution.

Roundness and Sphericity

Sphericity was measured using Wadell's method (in Krumbein and Pettijohn, 1938) and roundness was assessed using silhouettes in Pettijohn (1949). Comparisons of the roundness and sphericity means of the samples were achieved using the Student's t-distribution.

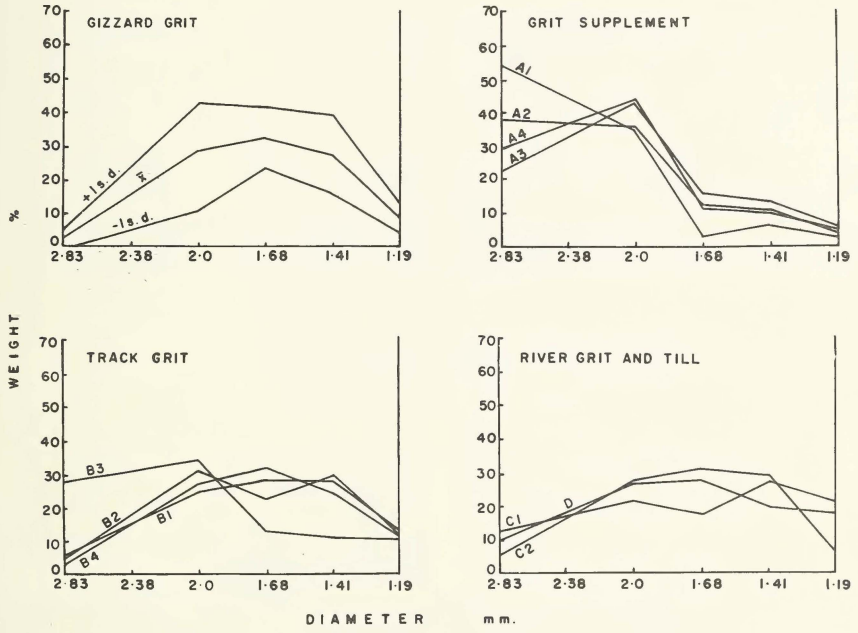

Figure 2. Graphs showing weight percent catchments of the grit samples. The gizzard grit graph shows the mean curve for all 16 samples and one standard deviation on either side. As these are catchments, the actual diameters of the particles will be greater than the mesh diameter of the sieve. Sieve 6 = 2.83 mm., sieve 8 = 2 mm., sieve 10 = 1.68 mm., sieve 12 = 1.41 mm. and sieve 14 = 1.19 mm. The scale on the x axis is logarithmic and follows the "phi-scale" (see Krumbein and Pettijohn 1938) expressed in millimetres.

Table 2. Chi-squared values for the size percentages of the moor grit samples as compared to the (expected) frequency of the gizzard grit.

Sample No.	Chi-squared with 4 deg. of freedom	p
A1	1279.9533	<0.001
A2	597.6366	<0.001
A3	211.1226	<0.001
A4	269.8148	<0.001
B1	6.2232	0.20 — 0.10
B2	6.4049	0.20 — 0.10
B3	309.5498	<0.001
B4	1.2340	0.90 — 0.80
C1	69.0982	<0.001
C2	4.7731	0.50 — 0.20
D	32.7733	<0.001

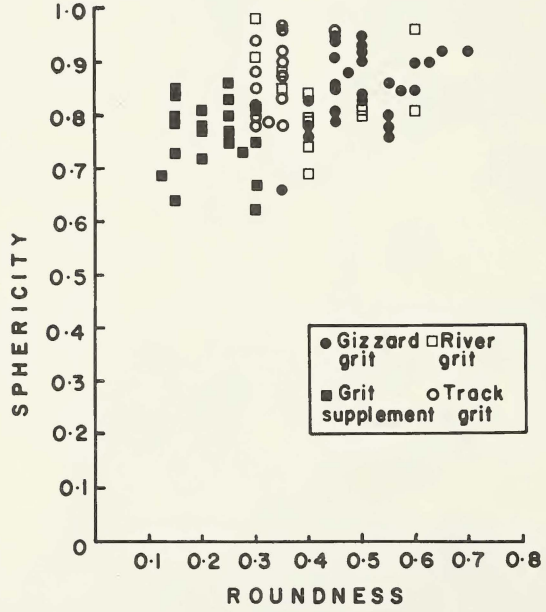

Figure 3. Graph showing correlation between roundness and sphericity values of the grouped samples.

Figure 3 gives the roundness and sphericity values for gizzard grit, grit supplement, river grit and track grit. Tables 3 and 4 give results of t-tests showing the significance of the differences between the roundness means and sphericity means respectively.

Mineralogy

The gizzard grit was composed almost entirely of opaque white quartz grains showing traces of iron staining. A few clear quartz grains were observed. These were polished and had an iridescent lustre. Evidence of the former presence of feldspar associated with the quartz was provided by rhomboidal pits in the surface of the grains.

The grit supplement was composed predominantly of clear and opaque quartz grains. Some shell fragments had been added to aid in egg production.

Grit from the surface of the track was composed mainly of opaque milky quartz. Feldspar crystals could be seen on many of the quartz grains. It is probable that this is derived from the Millstone Grit, which, when fresh, is composed of 97% quartz, 3%feldspar and rock fragments.

The samples of river grit were composed of Millstone Grit rock fragments and some white quartz grains. The till sample contained many particles of fractured quartz and rock fragments, and a large amount of clay and powdered quartz.

DISCUSSION

The size frequency analysis of the gizzard grit showed that the optimum size for the grouse is from about 1.3 mm. to 2.2 mm. in diameter. The grains making up the grit supplement are, on the whole, too large to be easily swallowed by the grouse. Both till and river grit contain particles of the right size for the grouse, but of these only C1 is shown to be a likely source by the chi-squared test. Three of the track grit samples are shown to be likely candidates for gizzard grit by the chi-squared test.

The particles of grit found in the gizzards had high sphericity values (mean 0.85). Rounding, caused by abrasion, is positively correlated with sphericity, but the degree of sphericity is mainly governed by the initial crystal shape. The high sphericity values shown by gizzard grit cannot be entirely explained by abrasion in the gizzard.

Smith and Rastall (1911) found that quartz was always present in gizzards obtained from wild Red Grouse, even if this mineral was uncommon in the locality. Quartz is also preferred

Table 3. Significances of the differences between the roundness means of the grouped samples and the mean for the gizzard grit. Note the very high t value for the grit supplement.

Type of Grit	t	Deg. of freedom	p
Supplement.	4.4225	45	<0.001
River.	1.0490	42	>0.1
Track.	1.0806	44	>0.1

Table 4. Significances of the differences between sphericity means of the grouped samples and the mean for the gizzard grit. River and track grits are not significantly different from gizzard grit.

Type of Grit	t	Deg. of freedom	p
Supplement.	14.0265	45	<0.001
River.	2.7081	42	$0.02 - 0.01$
Track.	7.9722	44	<0.001

CORRECTION: the legends to tables 3 and 4 are transposed.

by the Willow Grouse, *Lagopus lagopus lagopus* (Kolderup, 1923) and the North American Ruffed Grouse, *Bonasa umbellus* (Bump *et al.*, 1947). This mineral alone was found in the crops of the East Greenland Ptarmigan, *Lagopus mutus* (Getting, 1937). The Icelandic grouse, which has difficulty in obtaining quartz, uses volcanic rocks and glasses (Kolderup, 1923).

Most game-birds seek out the hardest rocks and minerals in the area. It seems likely that the birds form a specific search image for these minerals, as they do when feeding on tipulids (Butterfield and Coulson, 1975). Colour, size and shape (sphericity and roundness) may be used as selection criteria. No calcium carbonate was found in the gizzard grit. The harsh physical and chemical action of the gizzard may have removed the evidence. If the birds search for hard minerals when gritting, shell fragments, which are fairly soft, would probably not be chosen.

Conclusion

By far the most abundant source of grit on the moor is exposed on the surface of the shooting track. The grit from here was found to be the most similar, in all parameters studied, to that found in the gizzards. The other natural grits may be equally suitable for the birds but are restricted in areal extent. The grit supplement was not utilised by the grouse, although the presence of droppings near some piles indicates that they may have been investigated. Supplementary grit may be attractive to grouse by its white colour but is too large and of the wrong texture to be of use in the gizzard. Additionally, supplying artificial grit in an area of abundant natural grit supply seems to be a futile practice.

Acknowledgements

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