

A preliminary study of the feeding of the Greenland White-fronted Goose *Anser albifrons flavirostris* in Cardiganshire

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Introduction

The Greenland White-fronted Goose *Anser albifrons flavirostris* occurs principally in the western and northern areas of the British Isles. The main concentration is in Ireland, where perhaps three-quarters of the population overwinter. The remainder inhabit remote districts of west Scotland, from Kirkcudbright through Argyll to the Outer Hebrides, apart from smaller groups in Lancashire and Wales (Atkinson-Willes 1963). The race is not as well documented as the European White-fronted Goose *A. a. albifrons* on account of the inaccessibility of many of its haunts.

The British population of *A. a. albifrons* represents between 12 and 20 per cent of the race, whereas that of *A. a. flavirostris* (including the Irish component) comprises essentially the entire population of the race. It is most important, therefore, that knowledge of its ecology is adequate for a sound conservation policy.

Until recently, a population of about 500 Greenland Whitefronts overwintered at Cors Tregaron National Nature Reserve in Cardiganshire. Numbers declined markedly during the severe winter of 1962-63, and have rarely exceeded 100 in subsequent years. Under the direction of the Regional Office of the Nature Conservancy, a preliminary study of geese on the reserve was carried out during winter 1964-65. In collaboration with the Wildfowl Trust, the investigation was intensified with a survey of vegetation in summer 1966, based on existing knowledge of feeding habits of the geese, and was followed by a feeding study in winter 1966-67. The summer work was supplemented by surveys of upland bogs in the vicinity of Cors Tregaron N.N.R. which were known to have been frequented by Greenland Whitefronts in previous years. For comparative purposes, the proposed nature reserve at Borth Bog, used as a feeding area by a small population of White-fronted Geese



Plate IX. (a) A Dragon Rapide after a (routine) landing on the sands of Barra, Outer Hebrides, during an aerial survey of Barnacle Geese. (See p. 97).
(b) Roanish Island, typical winter haunt of Barnacle Geese.

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Plate X. Inside the new Tropical House at Slimbridge. (a) The general view towards the waterfall pond, which is shown (b) in close-up. (See p. 169)

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reported as *A. a. albifrons*, was also investigated.

The first part of this paper deals with the various surveys carried out in Cardiganshire in summer 1966. In the second part, results are presented for the preliminary feeding study of 1964-65 and a food analysis scheme developed in 1966-67. Results are discussed in relation to the summer investigations.

PART I. Survey of vegetation at Cors Tregaron N.N.R. and other sites in Cardiganshire.

Study sites

Cors Tregaron N.N.R. occupies an area of 1,898 acres (769 hectares) in mid-Cardiganshire about 12 miles (19.3 km.) from the sea, at an altitude of about 500 ft. (162 m.) a.s.l. The reserve is surrounded by hills up to 1,000 ft. (352 m.) a.s.l. and is centred on three adjacent raised bogs, known as the Western, North-east and South-east Bogs. The bogs are separated from each other by promontories of rising land and by streams flowing through the reserve. These include the River Teifi and its tributaries the Camddwr and the Ffluv. These watercourses have developed narrow river terraces.

A full description of Cors Tregaron may be found in Godwin and Conway (1939). In brief, each bog is characterized by purple moor-grass *Molinia caerulea* at its higher levels, giving way to deer-grass *Trichophorum cespitosum*, pool and hummock areas (bog-moss *Sphagnum* spp. and cotton-grass *Eriophorum* spp.) and heather *Calluna vulgaris*. The development of these associations varies considerably according to area, and to the extent of previous peat extraction. A peripheral zone known as the Rand may separate the bog from river terrace. To the north, river terraces are broad and are characterized by rush *Juncus* and marsh willow *Salix* swamp. To the south, *Juncus* diminishes to pasture close to the river. The pasture is grazed by sheep and ponies.

In contrast to Cors Tregaron, Borth Bog lies almost at sea level, covering an area of 1,352 acres (547 hectares) close to the Dovey Estuary in north-west Cardiganshire. This proposed reserve is centred on a single raised bog which is surrounded by reed *Phragmites communis* swamp and *Juncus* marsh. Drainage channels include the River Leri, now in canalised form, and the Pwll Ddu.

Other sites investigated include small upland bogs of Llyn Eiddwen, Llyn

Fanod, Llyn Garn Fach and Pwll-yr-uch. These bogs lie a few miles to the west of Cors Tregaron.

Methods

A small number of plant species have been previously recorded as food sources for *A. a. flavirostris*. These include deer-grass *Trichophorum cespitosum* which was reported by Campbell (1947) from Whitefronts shot in North Uist, and common cotton-grass *Eriophorum angustifolium* and white beak-sedge *Rhynchospora alba* which were found in Whitefronts shot near Cors Tregaron (Cadman 1953, 1956). Special attention was paid to these plants in each part of the summer survey.

The region of particular interest at Cors Tregaron was the pool and hummock area of the Western Bog, since it was here that geese had been most frequently observed during the preliminary survey of 1964-65. Frequency distribution of plant species in this area was determined using 30 cm. × 30 cm. random quadrats. A similar analysis was carried out in the *Trichophorum* zone of the Western Bog, and in the pool and hummock area of Borth Bog.

Surveys of the smaller bogs were limited to the compiling of plant species lists and general description of vegetation.

The location of food parts of *Rhynchospora* and other recognised food plants at Cors Tregaron was considered in terms of depth within the substratum and its hardness. Usually, depth of food-stuff could be measured after pulling entire plants from the peat. Hardness of the peat was determined using a 34 cm. spear, weighing 73 g. The spear was prepared from 5 mm. steel rod, with a filed point and metal flights to ensure a vertical drop. Graduations of 1 cm. were marked along its length. The spear was dropped into sample areas from a height of 50 cm. (from the flights); penetration was recorded for 10 drops in each of 20 quadrats. Percentage cover was estimated by eye for each plant species within quadrats.

Results

(a) Comparison of vegetation within Cors Tregaron and Borth Bog.

Frequency of species is given in Figure 1. The most pronounced difference between pool and hummock areas of the two raised bogs occurred in the distribution of bog myrtle *Myrica gale*. This species was a prominent feature of Borth Bog but was not observed at Cors Tre-

Wildfowl

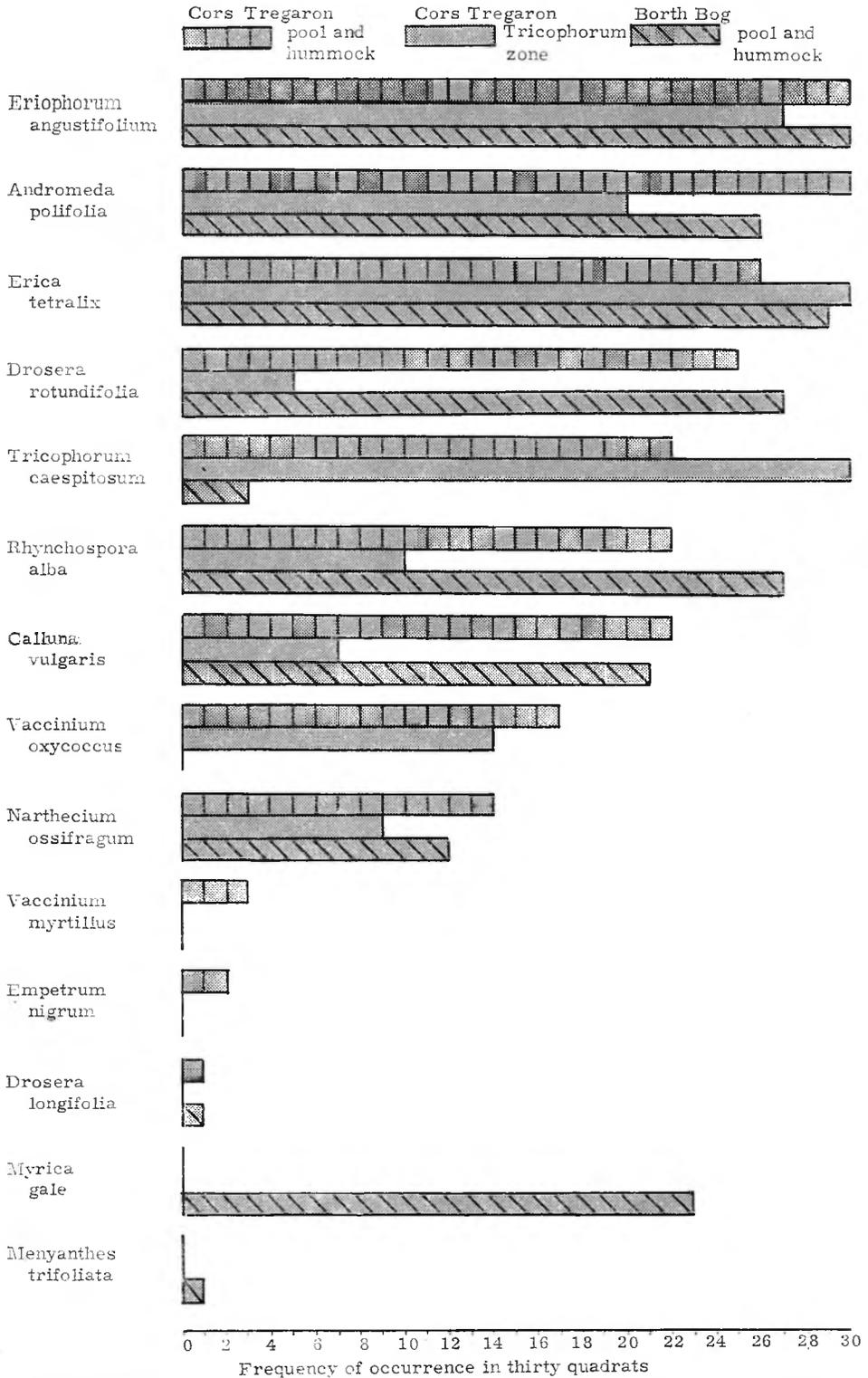


Figure 1. Frequency of plant species in 30 cm. x 30 cm. quadrats at Cors Tregaron and Borth Bog.

garon. *Trichophorum* was more abundant at Cors Tregaron but there were no marked differences in distribution of other food plant species.

The *Trichophorum* zone of Cors Tregaron is characterized by a decline in every species other than *Trichophorum* and cross-leaved heath *Erica tetralix*. These changes reflect the drier soil conditions as compared with pool and hummock areas.

(b) Upland bogs in the vicinity of Cors Tregaron.

Prior to winter 1962-63, *A. a. albifrons* inhabited some of the smaller bogs and lakes near Cors Tregaron. Of these, Llyn Eiddwen was one of the more frequently used. The lake is about 500 m. long by 250 m. wide. A small bog, extensively cut for peat in the past, exists at the south end. *Eriophorum* was very abundant, with a little *Trichophorum*. *Rhynchospora* was absent. Observations by one of the authors (Pollard) in November and December 1962 showed that this bog was certainly used for feeding by geese.

Llyn Fanod lies about two miles (3.2 km.) south of Eiddwen; although similarly free from disturbance, Llyn Fanod is not known to have been used by geese. This is possibly explained by the fact that the adjacent bog comprised essentially *Juncus* marsh, in contrast to the artificial pools and hummocks in the peat-cutting area of Eiddwen.

Llyn Garn Fach is a very small and exposed hill tarn, on which geese are reported to have roosted occasionally. The surrounding bog comprised mainly *Jun-*

cus, but there was also pool and hummock development.

Pwll-yr-uch has no permanent water but comprises about 10 acres of bog, much of it 'quaking'. *Eriophorum* was very abundant. The bog was used by geese particularly when disturbed on Llyn Eiddwen.

(c) Depth of foodstuffs in substratum.

As shown in Table I, depth of foodstuffs varied appreciably. The most readily accessible appeared to be *Rhynchospora* bulbils; these were often located above the peat surface, with roots penetrating *Sphagnum* before entering the peat.

Depth of *Eriophorum* roots varied according to site. Only 10-15% could be extracted with roots attached by hand-pulling and the force required to lift intact plants was considerable. It seems likely that this food must be at least partly excavated by the geese—a difficult process under freezing conditions—before being eaten.

Depth of *Trichophorum* shoot bases varied according to the age of tussocks. Whilst generally quite shallow, shoots of this species also were difficult to extract, owing to the formation of a tough mat of fibrous roots in the tussock.

(d) Hardness of substratum.

Plant cover is presented diagrammatically in Figure 2 for each of four classes of peat hardness, as indicated by mean depth of penetration of the spear described above.

Certain species showed a distinct correlation with hardness of substrate. Thus, *Sphagnum* species were considerably more abundant in softer areas. *Rhynchospora* appeared to grow mainly in areas of

Table I. Depth of shoot base in various plant species on Cors Tregaron.

Species and parts eaten	Site	Av. depth (cm.)	Standard error	Substratum level
White beak-sedge (bulbils) <i>Rhynchospora alba</i>	Shallow pools	2.02	0.10	Peat surface
	Wet <i>Sphagnum</i>	3.13	0.26	<i>Sphagnum</i> , upper surface
	<i>Calluna/Erica</i> assoc.	0.90	0.09	Peat surface
Common cotton-grass (roots) <i>Eriophorum angustifolium</i>	Shallow pools	7.97	0.35	Peat surface
	Wet <i>Sphagnum</i>	13.16	0.46	<i>Sphagnum</i> , upper surface
	Drier <i>Sphagnum</i>	7.60	0.37	<i>Sphagnum</i> , upper surface
	<i>Calluna/Erica</i> assoc.	9.27	0.56	Peat surface
Deer-grass (bulbils) <i>Trichophorum cespitosum</i>	Old tussocks	4.60	0.36	Tussock surface
	Young tussocks	1.51	0.09	Tussock surface

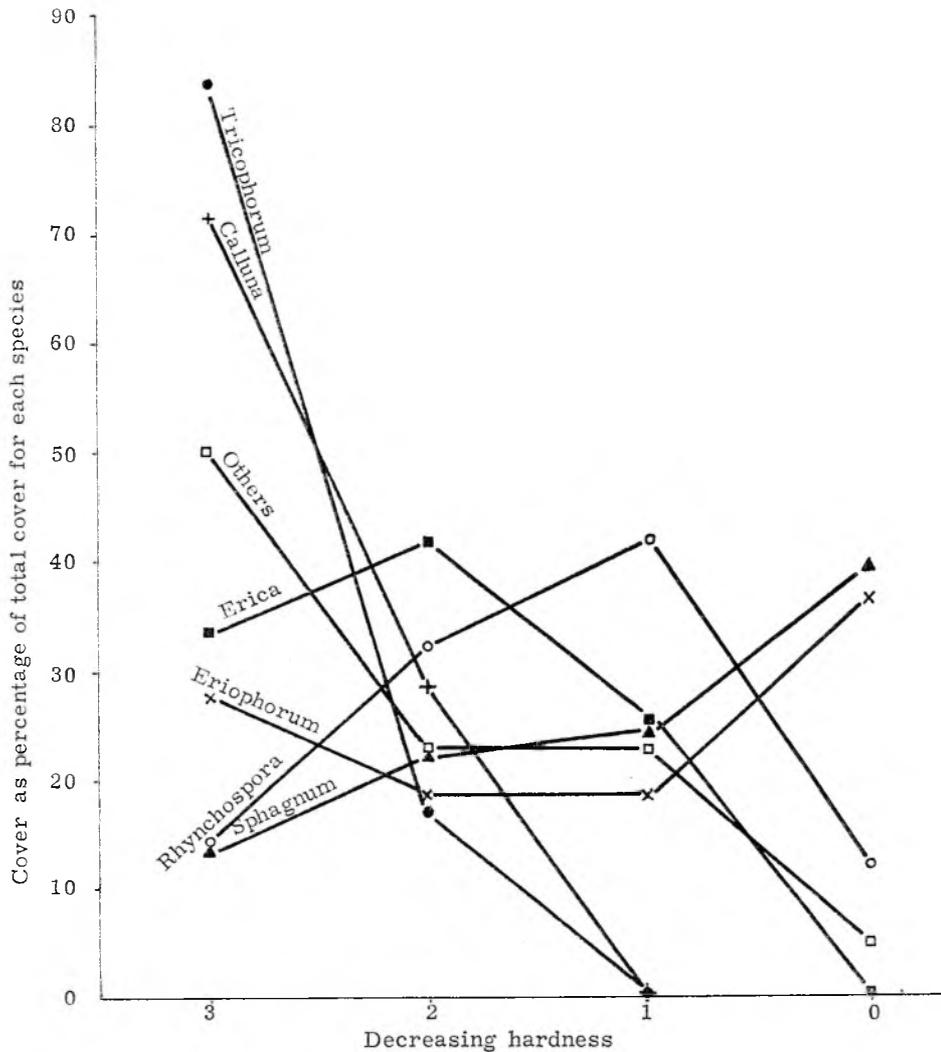


Figure 2. Plant cover in relation to hardness of substratum.

intermediate hardness, not tolerating the very soft ooze in pools. (At Borth Bog it was abundant in firm and comparatively dry peat of old peat-cutting and fire zones. Apparently this species, a coloniser of pools on the raised bog, tolerates harder peat in the absence of strong competition from species such as *Calluna*, *Erica* and white fork moss *Leucobryum glaucum*.) *Eriophorum* showed a broad tolerance range; *Trichophorum* was confined mainly to firmer areas. Resistance to penetration in tussocks was comparable to that of hard-packed peat.

PART II. Studies in feeding habits of Greenland White-fronted Geese in Cardiganshire.

Background

The fact that *A. a. flavirostris* was not recognised as distinct from *A. a. albifrons* until comparatively recently (Dalgety and Scott 1948) complicates evaluation of earlier feeding studies on White-fronted Geese. Campbell (1947) reported two instances of bulbils of *Trichophorum* found in the crops of Greenland Whitefronts shot in North Uist. The only other records are in Cadman (1953, 1956) who found roots of *Eriophorum* and young

shoots of *Rhynchospora* in viscera of geese shot in the vicinity of Cors Tregaron. Each of these records refer to material collected through viscera analysis of shot birds. The technique of viscera analysis for investigation of wildfowl feeding habits has been described by Harrison (1960) and has been used extensively in studies of several species of duck, e.g. Olney (1964). Generally, however, viscera analysis may be used only for quarry species, since the researcher is usually dependent on wildfowling for the supply of study material. Whilst *A. a. flavirostris* is on the shooting list, its distribution is such that much of the British population is afforded protection through remoteness or preservation of its wintering areas. In addition to difficulties in obtaining material from such locations, it is undesirable that further reduction of a small population should occur through such sampling techniques.

An alternative approach to wildfowl food analysis was adopted by Ranwell and Downing (1959) in a study of feeding pattern in Brent Geese *Branta bernicla*. Faeces of this species were found to be suitable for food determination through microscopic examination of plant remains. This technique had already found application in feeding studies of rabbits (Dusi 1949) and has been frequently employed in investigations of range habits of herbivores (Stewart 1967). Faeces analysis offers the special advantage in wildfowl feeding studies that the size, number and frequency of samples is limited only by the amount of disturbance imposed on the birds in collecting material. It is therefore very suitable in situations where conservation of the local population is of special importance, and where access is fully controlled. For this reason, faeces analysis was employed for the 1966-67 feeding study of *A. a. flavirostris* at Cors Tregaron National Nature Reserve.

Methods

The preliminary study of 1964-65 was based on direct observations by the previous Warden-Naturalist, Mr. P. J. Panting. On each of 23 occasions, a nine mile (14 km.) transect about 400 yards (370 m.) wide was surveyed. Date of observation and location of groups of feeding birds were recorded on a large-scale map of the reserve.

In preparation for the feeding study of 1966-67, samples of known food plant parts, and material of associated plant species, were gathered in late autumn 1966. Permanent mounts of sections show-

ing diagnostic features within the upper and lower epidermal surfaces were prepared by the method outlined by Metcalfe (1960), for reference purposes in subsequent microscopic examination of faeces. The reference collection was supplemented by material gathered during winter 1966-67.

Collection of faeces commenced immediately after the arrival of geese in October 1966. Thirty faeces were collected by the Warden-Naturalist, Mr. P. Davis, at approximately three-week intervals, and were immediately despatched to the Wildfowl Trust for analysis. Upon arrival, six were randomly selected from the sample and sealed individually in tubes containing formal acetic acid (FAA). The frequency of sampling was increased in March 1967 when changes in composition of the droppings were observed. Collection and subsampling procedures were such that it could be reasonably assumed that each dropping originated from a different bird.

Faeces were prepared for analysis by crushing in FAA a few days after fixing. Separation of plant fragments was found to be facilitated by the fixing procedure. Ten portions of slurry from each faeces were examined for component plant species. Presence or absence only was resorted to after attempts to quantify the occurrence of each species proved unsatisfactory.

Results

(a) Preliminary survey 1964-65.

Locations of feeding geese during 1964-65 are shown in Figure 3(i) in relation to minimum ground temperature as recorded for the preceding 24 hours at Swyddffynon meteorological station on the edge of Cors Tregaron N.N.R. In a total of 23 observations, geese were feeding on raised bog on 19 occasions, and on pasture (mainly river terrace) on 13 occasions. Birds were seen in both areas on 10 days, indicating movement or splitting of the flock. There was an increase in use of pasture after November; in general, feeding station did not appear to be associated with temperature.

(b) Droppings analysis and direct observations, 1966-67.

Faeces analyses resulted in strikingly few species being identified as food plants and for much of the winter feeding appeared to be confined to bulbils of *Rhynchospora alba*. It should be noted, however, that geese and fresh droppings could not always be located within the reserve (hence the irregularity of

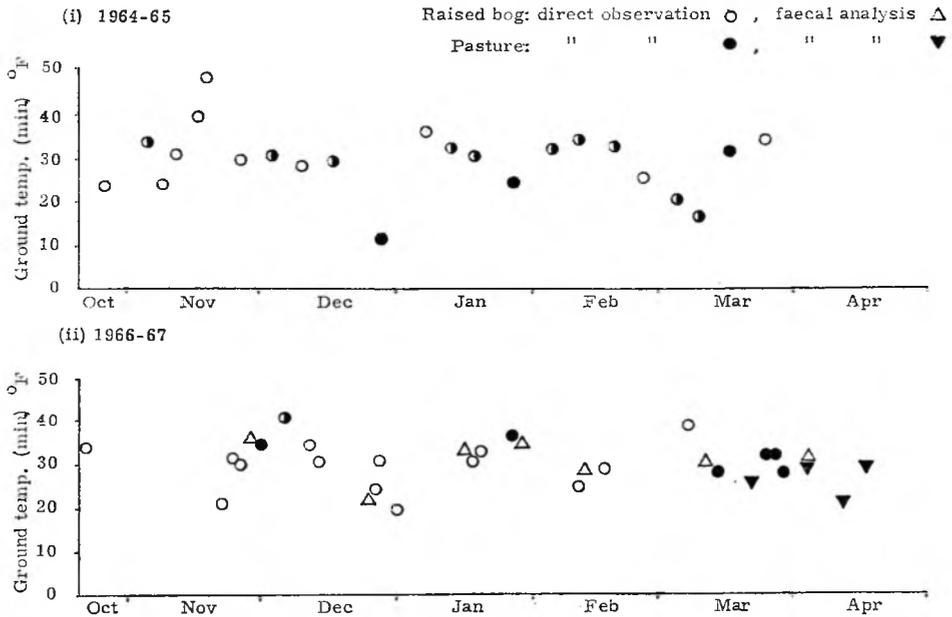


Figure 3. Location of feeding geese in relation to ground temperature, Cors Tregaron, 1964-65 and 1966-67.

samples); since *Rhynchospora* appeared to be confined to Cors Tregaron in that particular region, it is most unlikely that the diet of geese was as unvaried as is suggested.

Not until the middle of March did sample droppings contain species other than *Rhynchospora*. In every case, identifiable droppings contents reflected those species occurring in the area from which the sample was collected. In late March and April, the most common material in droppings was foliage of common bent-grass *Agrostis tenuis*. This was also the most abundant species in the turf of river terraces. Reed-grass *Glyceria* spp., common in wetter sections of terraces, was detected. Tufted hair-grass *Deschampsia cespitosa* was taken frequently towards the time of departure of the geese (18th April 1967), and in two instances comprised over 50% of droppings material. Dicotyledonous foliage occasionally formed a substantial proportion of droppings from river terraces, but could not be identified further.

Direct observations on feeding geese for winter 1966-67 are shown in Figure 3(ii). Prior to mid-March, birds were observed feeding on pasture on only three occasions; there was no indication of a temperature effect on feeding station. Direct observation supported the evidence from droppings analysis of a change in

feeding habits in mid-March. In 1964-65, pasture grazing was frequent throughout the winter. Feeding pattern in late March and April of that year could not be observed due to earlier departure of the geese.

Discussion

There is little doubt that the drastic decline in the population of *A. a. flavirostris* at Cors Tregaron in winter 1962-63 was associated with the very severe conditions at that time. Markgren and Mathiasson (1963) concluded that premature departure from feeding grounds under adverse conditions reflected limited food supplies rather than a direct response to the weather. However, the reduction in numbers at Cors Tregaron was permanent, and is believed to have resulted from the combined effects of starvation and shooting. In 1967-68 no geese were observed on the area (P. Davis, pers. com.).

By virtue of its status as a National Nature Reserve, Cors Tregaron affords complete protection of its fauna and flora (section 16, National Parks and Access to the Countryside Act 1949). In the case of a quarry species such as *A. a. flavirostris*, however, protection is limited to the scheduled area of the reserve. Under normal conditions, the species fed within this area for much of the winter, as in-

licated by observations in 1964-65 and 1966-67, although visits to remote upland bogs were not unusual in previous years. However, in 1962-63 geese moved out of the reserve into agricultural areas, presumably in search of food, and in consequence were subject to unusual shooting pressure.

According to observations reported in this and other papers (see above) the food plants of *A. a. flavirostris* include *Eriophorum angustifolium*, *Rhynchospora alba*, *Trichophorum cespitosum* and a number of grasses of which *Agrostis tenuis*, *Deschampsia cespitosa*, Yorkshire fog *Holcus lanatus* and *Glyceria* spp. appear to be important. Study of distribution of the first three foodstuffs in peat at Cors Tregaron suggested that *Eriophorum* roots would be the least available under severe conditions. *Deschampsia* bulbils would probably be available even with deep snow cover, but there are no records of these being consumed by geese in Cardiganshire. *Rhynchospora* bulbils occur at very shallow levels and are often developed within the overlying *Sphagnum*. Even under very cold conditions, this food would still be available, and could be readily obtained during periods of snow cover. Cadman (1956) reached similar conclusions.

In 1966-67, and probably in 1964-65 also, *Rhynchospora* was an important food from the time of arrival of the geese until shortly before their departure in spring. *Eriophorum* was not detected in any droppings samples analysed. Both droppings analysis and direct observations made on the reserve also indicated that pasture was an important source of food. There is also a substantial unknown element in the winter nutrition of these geese. There appears to be no reliable information on the location and feeding habits of the birds when not within the confines of Cors Tregaron N.N.R., apart from observations made on the larger population prior to 1963-64 (Cadman 1953, 1956). There was a pronounced change in feeding pattern shortly before departure of geese in April 1967, when feeding took place predominantly on grasses (river terrace) instead of *Rhynchospora* (raised bog). (It is interesting to note that geese were claimed by local farmers to be of considerable nuisance on early pasture grass and winter wheat when the population numbered several hundred.)

The reasons for this change are obscure. Possibly changes occurred in the nutritive value of either food items, for ex-

ample, a lower protein content in rapidly-expanding *Rhynchospora* bulbils, or an increasing protein level in grasses. In an investigation of *A. a. albifrons* at Slimbridge, Gloucestershire, Kear and Pollard (unpublished) found substantial increases in protein levels in the early spring of 1966, not only in grass foliage extracted from viscera, but also in droppings and random clips from the feeding area.

A similar increase in the use of uncultivated grassland in early spring was observed by Markgren and Mathiasson (1963) in a study of Bean Geese *Anser fabalis*. These authors also found *Deschampsia cespitosa* to be an important food plant of this species in some localities. The increasing frequency of *Deschampsia* utilization at Cors Tregaron towards the time of departure in 1967 is especially interesting, since it is generally regarded as being a poor source of food for herbivores.

The only known major sources of *Rhynchospora* in north-west Cardiganshire are Cors Tregaron and Borth Bog. Feeding areas and habits of the population of *A. a. albifrons* at Borth Bog have not been fully investigated, but most reports suggest that feeding occurs in the *Trichophorum* and peat-cutting zones at the south end. However, these geese have also been observed feeding on grazed pasture in January and March 1967 and, somewhat surprisingly, on mud within the tidal zone of the Dovey estuary, which was later shown to hold quantities of crustaceans *Gammarus* sp. and molluscs *Hydrobia* sp. Despite the similarities between available feeding grounds at Borth Bog and Cors Tregaron—as shown from the summer surveys of 1966—there has been no indication that geese from the latter site use Borth Bog as an alternative feeding area.

Acknowledgements

The authors wish to express their gratitude to Mr. P. Davis for his help in collecting material and recording observations at Cors Tregaron, Mr. P. Panting for his assistance in 1964-65 and Mr. E. D. Williams for his observations on upland bogs near Tregaron. Dr. G. V. T. Matthews, Dr. D. S. Ranwell and Mr. H. Boyd provided useful criticism of the draft paper. Appreciation is also extended to the Nature Conservancy in providing access and laboratory facilities for the summer survey of Cors Tregaron.

The 1966 summer survey and 1966-67

feeding investigation was carried out under the auspices of the Wildfowl Trust, and was grant-aided by the Natural Environment Research Council.

Summary

An investigation of feeding habits of Greenland White-fronted Geese *Anser albifrons flavirostris* in Cardiganshire was commenced in winter 1964-65, following a drastic decline in the population in 1962-63. A survey of feeding grounds was made in summer 1966, followed by an intensive study of feeding habits in winter 1966-67, in which the technique of faeces analysis was employed. During much of the winter the preferred food plant species taken at Cors Tregaron was white beak-sedge *Rhynchospora alba*. Various grass species were also taken, particularly in spring. Temperature did not appear to be an important factor of feeding pattern, although there were indications that certain foodstuffs would not be readily available under severe conditions.

The technique of faeces analysis is discussed in relation to research into feeding habits of disturbance-sensitive species.

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