RIDLEY, H. N., 1930. *The Dispersal of Plants Throughout the World.*

SAMUELSSON, G., 1922, Er ny Alisma-Art, *Svensk Bot. Tidskr.*, **16**, H.1.

———, 1932, Die Arten der Gattung Alisma L., *Arkiv for Botanik*, **24A** :**7**, 1-46.

———, 1933, *Alisma*, in Diels, L. & Samuelsson, G., *Die Pflanzenareale*, **3** :**8**, map 75.

SCHOTSMAN, H. D., 1949, Korte mededeling betreffende het geslacht Alisma in Nederland, *Ned. Kruid. Archief.*, **56**, 199-203.

STEUDEL, E., 1821, *Nomencl. Bot.*, **1**, 26.

TOURNAY, R. & LAWALRÉE, A., 1949, Les Alisma de la Flore Belge, *Bull. Soc. Roy. Bot. Belg.*, **81**, 47-49.

WEST, GEORGE, 1910, A Further Contribution to a Comparative Study of the dominant Phanerogamic and Higher Cryptogamic Flora of Aquatic Habit in Scottish Lakes, *Proc. Roy. Soc. Edinb.*, **30**, 65-181.

YOUNG, WILLIAM, 1936, A List of the Flowering Plants and Ferns recorded from Fife and Kinross (v.c. 85), *Trans. Bot. Soc. Edinb.*, **32**, 144.

THE DEVELOPMENT OF ORCHID POPULATIONS IN CLAYPITS IN COUNTY DURHAM

By J. A. RICHARDSON
King's College, Newcastle upon Tyne

INTRODUCTION

Changes, qualitative and quantitative, are always taking place in the general composition of a flora. At the present time considerable attention is being paid to modifications of the British flora that either appear to have occurred recently, or are still going on (cf. Lousley, 1953). Some reasons for these changes are, that during the past sixty years large areas of this country have undergone great alteration by the bringing of marginal lands into cultivation, by tree planting, by quarrying and coal mining, and in numerous other ways. The results of these disturbances have been two-fold, because, (a) certain habitats have been completely changed (e.g. by drainage) and the characteristic vegetation exterminated, (b) the formation of new types of habitats has facilitated the creation of many large thriving colonies of plants formerly very restricted in numbers.

County Durham, particularly the eastern half of the county, has not escaped these alterations to the countryside; indeed, in some districts the changes are as drastic as any to be found elsewhere in Britain. A new plant habitat is produced when clay, used in brickmaking, is extracted from the glacial deposits covering a large part of Durham. In the course of investigations into factors controlling the spread of plants from the surrounding countryside into the claypits at Birtley, some attention was given to the rapid local build-up of colonies of the dactylorchids *Dactylorchis fuchsii, D. purpurella* and their hybrids.

HISTORICAL

To appreciate fully the direction of migration and the extent of the influx of these orchids into the claypits it is essential to consider their past history in the Birtley area.

The earliest local record for the occurrence of the orchid now known as *D. purpurella* was made in 1896, when it was found growing on the sides of the railway cutting at Vigo (see fig. 1). It was stated that about 50 plants grew here. In parenthesis it is interesting to note that this plant was then locally called 'wild gladiolus'. To the north of Birtley a few scattered plants were found in 1909, along the Leybournhold Gill (LG in fig. 1) just before it passes under the main-line railway. Later, in 1928, a large colony grew in the meadow between the quarry (Q) and the

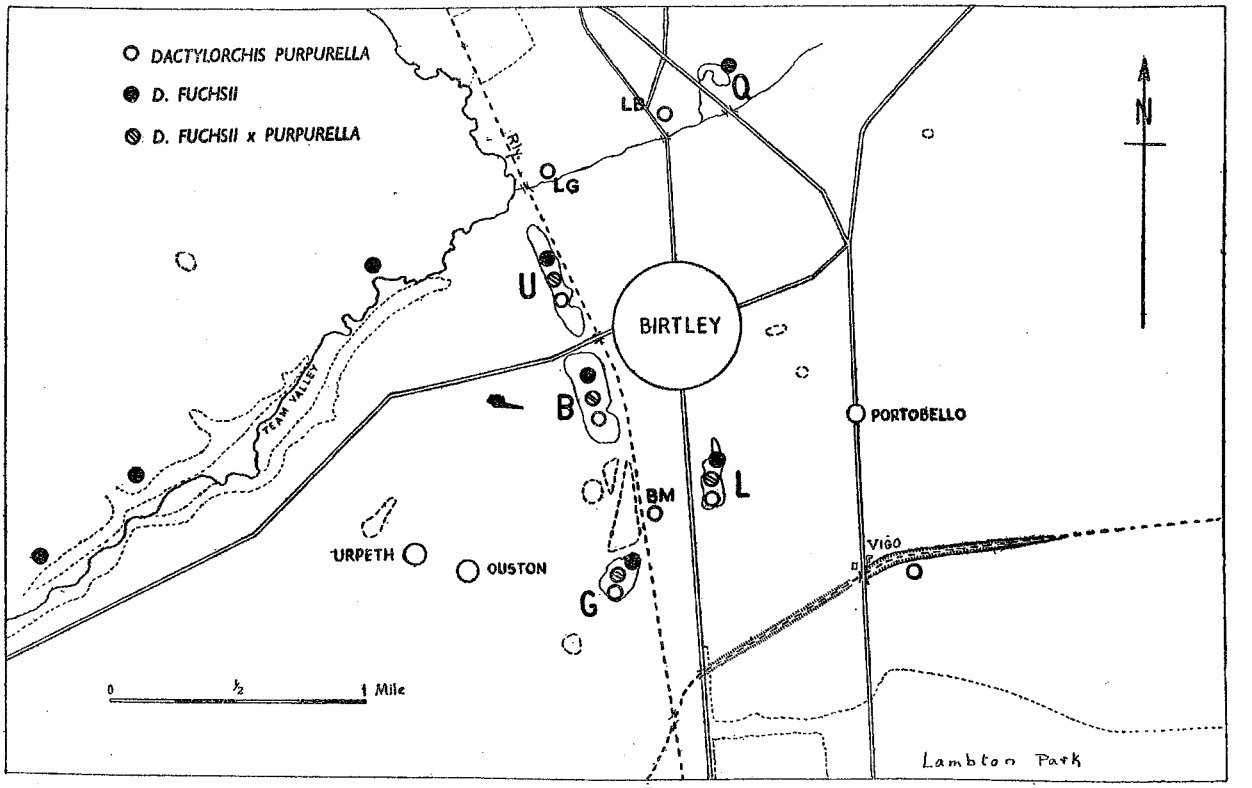

Fig. 1. Distribution of *Dactylorchis purpurella*, *D. fuchsii* and *D. fuchsii* × *purpurella* in the Birtley area.

Longbank (LB). In the two latter localities, *D. purpurella* had died out by 1930, and it has not appeared there since. Similarly, the station for the plant at the south end of Birtley Marshes (BM), first recorded in 1925, continued to exist for a few years, but, when the marsh was drained and the stream canalised early in 1930, the plant vanished.

Thus, between 1930 and 1940 it appears that the only local station for the species was at Vigo, i.e. about one mile to the east of the open ground in the clay-fields at Birtley Grange (G) and Leafield (L). The yearly average number of plants seen over the past three years at Vigo has been twelve; this represents about a quarter of the number said to exist sixty years ago.

At the beginning of the present century *Dactylorchis fuchsii* was found in groups of a few dozen plants at several points in the damp ground of the Team Valley below the Forge (see fig. 1). It is just possible that these colonies persist today in much reduced numbers, although careful searching has so far failed to bring them to light. However, a single plant was found in 1940 in a new locality about a mile lower down the Valley from the former colonies. In 1903, between twenty and thirty plants were discovered by the Brooms Burn, north of Urpeth, where they grew for about ten years and then gradually died out. Similarly a colony of about twenty plants was first recorded north of the quarry (Q) in 1903 and these also had died out by 1925. A most careful search in these places in recent years has failed to reveal a single specimen of this orchid.

Thus, it appears that in the past 50 to 60 years plants of both *D. purpurella* and *D. fuchsii* have existed in small numbers in places around Birtley. It is certain that by 1940 *D. purpurella* had died out, or had been exterminated, in all its former known localities except on the railway bankside at Vigo. The disappearance of *D. fuchsii* is equally certain, and in 1940 its only known locality was in the Team Valley, a mile and a half to the west of the Birtley brickyards. The evidence strongly favours the view that in 1940 these orchids, far from increasing their range and numbers, were just managing to hold their own in the Birtley area.

The Spread of Orchids to the Claypits

Between 1940 and 1942 these attractive plants appeared for the first time in the Grange claypit (G) (see fig. 1). They excited keen interest, more especially when later what was clearly a hybrid was also found. Between 1942 and 1949 the orchids had spread to the St. Bede (B), Team Valley (U), and Leafield (L) claypits, and to several suitable places elsewhere.

The clay workings at the Grange brickyard are in the form of a shallow oval basin with a uniform depth of about forty feet

and a diameter of about two hundred yards. The clay was worked down to the present level in two "cuts" each one removing a twenty foot layer of clay from the whole area. The second of these cuts was started from the south in 1936 and finished at the north end of the basin in 1942. In that year a few plants of *D. purpurella* were seen for the first time on the lower slopes at the south end, i.e. on ground first laid bare six years previously. No orchids were found on the upper slopes which carried an almost closed community in which *Agrostis tenuis, Arrhenatherum elatius, Dactylis glomerata, Equisetum arvense, Festuca ovina* and *Lotus corniculatus* were prominent members; neither were any found on the practically bare clay on the bottom of the pit, nor in the dense hawthorn scrub formed over the very old workings at the west side of the basin.

The absence of the orchids from the upper slopes, which in 1936 carried an open plant community (mainly *Agrostis tenuis, Holcus lanatus* and *Tussilago farfara*), suggests that until about 1940 they were not extending their range with anything like the vigour they showed later. In view of the conclusions that have been made about the pattern of the invasion by the two species (see below) it would seem that by the time the orchid invasion had gathered impetus in 1942 the upper slopes were too densely populated with tall grasses such as *Dactylis glomerata* and *Arrhenatherum elatius* to provide a suitable habitat. In contrast, the lower slopes carried the very open-type community mentioned above, so that there was no competition factor controlling the establishment of orchids. By 1945 there were numerous plants of *D. purpurella* on the slopes and a few had started invading the bottom of the claypit at the south end.

D. fuchsii began to invade the brickyard in similar manner, and by 1948 hundreds of both species and their hybrids were growing all over the bottom of the pit, extending to within 50 yards of the last area to be worked out at the north end. This area of clay, uncovered in 1942, was carefully examined in 1949, when the average number of flowering orchid plants in a ten-yard square was found to be 27; this total was comprised of almost equal numbers of the two parents with a few hybrids (see Table 1). As time went on the taller growing, more vigorous hybrids were found to survive and increase in number amongst the vegetation more readily than the lower growing *D. purpurella*. This thinning out process so far as *D. purpurella* was concerned was noticed in all the other clay pits examined. Amongst the hybrids many forms were to be seen, ranging from almost pure *D. purpurella* plants through distinct intermediate plants to specimens of almost pure *D. fuchsii*. In 1953 there was no doubt that the hybrid was very rapidly gaining ground, as the average counts in a ten-yard square shows (see Table 1).

TABLE 1.

Species	Number of plants			
	1949	1951	1953	1954
Dactylorchis fuchsii	11	20	28	30
D. purpurella	12	14	10	8
D. fuchsii × *purpurella*	4	31	154	181

It is interesting to note that at the present time in the closed scrub communities along the west side, and along the upper slopes of the south, east and north sides, only a few orchids are to be found, even at what might well be the peak of the invasion pressure. It appears that generally no orchid plants, not even the hybrids, establish themselves in tall-growing vegetation in claypits.

A similar successful colonisation of recently bared clay also occurred at the St. Bede's brickyard (B) (see fig. 1). This working runs north and south, is about seven hundred yards long, and has a fairly uniform width of about two hundred yards. The clay was taken off, starting from the north end, and by 1928 the working face was at about mid-point of the yard.

The portion of ground cleared in 1930 has not been disturbed in any way since, so that when the first orchids were discovered growing on it in 1942 it had been open to plant invasion for twelve years. It then carried the typical open community described above, and it would appear from our present knowledge of the conditions necessary for the germination and establishment of *Dactylorchis purpurella* and *D. fuchsii* (see below) that in 1942 the habitat was most suitable. No plants were found on the younger ground to the south or in the more mature grassland and scrub farther north. Thus, the distribution of the earliest invading plants followed the same pattern as the one described for the Grange claypit. On the '1930 ground' the orchid population, comprising *D. purpurella, D. fuchsii* and every conceivable intermediate form, increased rapidly in numbers between 1942, when the parent plants were first discovered there, and 1952. At the present time although the ground still carries hundreds of orchids per ten-yard square there are signs that the numbers are no longer increasing; in fact as taller-growing grasses such as *Arrhenatherum elatius* and *Dactylis glomerata* spread into the area from adjacent ground to the north, the dominance of the orchids might be expected to decline. In view of the well-known characteristic of British orchids of fluctuating in abundance from year to year, a discussion of the results of fixed quadrat counts would be out of place for at least another three years. The fact that only a few scattered plants of the hybrid have ever been found growing on ground where there was a complete cover of

vegetation (in 1942) shows the difficulty orchids have in moving to closed communities on clay soils, and hints that as time passes they may be gradually eliminated from habitats in which they were pioneers.

In 1939 the St. Bede's claypit reached its present southern limit, except for a block of clay 60 yards wide × 10 yards deep × 6 yards high. Work was stopped in December 1939 when the kilns and drying sheds were required for the manufacture of war materials, and the clay-field lay undisturbed from then until October 1946. Pumping of water, however, took place at intervals to prevent severe flooding. During the seven years, 1939-46, the characteristic early colonising vegetation (see p. 357) moved in on both the bottom and sides of the claypit from the north right down to the last working face at the south end.

In 1946, just before this last block of clay was taken out, the orchid population in the yard as a whole was as follows: on the '1930 ground' 400 yards to the north there were hundreds of all three plants; towards the south end the numbers fell off progressively until one reached the working face where only a few scattered plants occurred.

In June 1951, i.e. five years after this last block of clay was removed, the slopes carried an average of six orchids to a ten-yard square and in the bottom there was only an occasional plant. The ratio on the slopes was three plants of the hybrid *D. fuchsii* × *purpurella* to two plants of *D. purpurella* to 1 plant of *D. fuchsii*. Altogether there were 29 orchids in the portion stripped in October 1946. Fixed quadrats were laid down here, but unfortunately those on the bottom were wiped out when the present method of working the clay was being tested. However, those on the slopes have been regularly observed and gave the counts listed in Table 2.

TABLE 2.

Species	Average number of plants per ten-yard square quadrat				
	1951	1952	1953	1954	1955
Dactylorchis fuchsii ...	1	11	15	19	23
D. purpurella	2	4	5	5	8
D. fuchsii × *purpurella* ...	3	20	43	64	106

Precisely the same general pattern of build-up of the orchid population has occurred in the other two neighbouring clay-fields, the Leafield (L) and the Union (U) (see fig. 1), so that the tentative conclusions now drawn are based on observations made simultaneously at four similar areas all within one mile of each other.

DISCUSSION

It appears that shortly before 1942, for reasons not clear at present, the dactylorchids, *D. purpurella* and *D. fuchsii* burst out from their stations a mile to the east, and a mile and a half to the west respectively, of the Birtley claypits. This occurrence is all the more remarkable because it is certain that the same habitat conditions, existing in the years just before 1942, had existed in some parts of all these clayholes almost continuously from 1920 onwards. One could have expected the appearance of the orchids earlier, but the fact remains that the first plants appeared in 1942. The possibility that these rare and striking plants could have been overlooked must not be entirely discarded, although, for several reasons, this contingency is thought to be most unlikely.

The second important fact arising out of this study concerned the condition of the substratum on which the orchids were first able to grow from wind-borne seeds into flowering plants. This event took place, either on gentle slopes, or on well-drained sites at the bottom of the claypits where the ground was about 10 years old and the plant cover was between 45% and 55%. Briefly, it appears that young orchid seedlings would enjoy at least three advantages here. (a) There would be some protection from the effect of the sun's radiation, (b) the soil texture would be more open, and hence warmer in spring than raw clay, and (c) the presence of organic matter in the soil and the resultant bacterial or fungal activity could have resulted in a supply of suitable carbohydrates to the young seedlings. In any case, the magnificent sight of thousands of orchids crowding the ground in June and July emphasises the suitability of the habitat.

When a visit is made to the claypits during the short period in which the earlier-flowering *D. purpurella* and the later-flowering *D. fuchsii* are in full bloom together, the existence of an extensive array of different hybrid forms is immediately apparent. These hybrids vary from plants scarcely distinguishable from one parent, through a long series of intermediates, to those closely resembling the other parent. It appears that the orchid populations in the Birtley claypits are in fact hybrid swarms, built up as a result of F_1 plants back-crossing with the parents. This view is strengthened by the knowledge that the F_1 plants produce healthy capsules from which seeds are dispersed in the normal way.

It can be strongly argued that the important result of hybridisation of the two species is to prolong the life of the population in the claypits. The hybrids are taller and more vigorous than the parents, and they can thus compete more successfully with the grasses and the hawthorn scrub. It is particularly noticeable that as the tall grasses invade the '1930

ground' (see above) the parent species, *D. purpurella* and *D. fuchsii* are the first to disappear, while the hybrid continues to flourish. Again, when orchid plants are found at scattered points in the hawthorn scrub, having arrived there long after the community was closed, they always prove to be the hybrids and never one of the parent species.

It is interesting to speculate upon the reason for the ease with which the hybrids can exploit recently exposed ground (as distinct from that favoured by the parent). This could be explained on the basis of the process of introgressive hybridisation throwing up a very large number of segregates. Since each will have particular physiological requirements at least some of them could find tolerable habitats at points on newly turned up clay. As Anderson (1949) has argued, for *Iris* species, the success of these orchid populations may be due to hybridisation between closely related species, followed by the habitat selecting from large numbers of plants which embrace a wide range of ecological tolerances.

Clearly, the value of any account that deals with changes in the vegetation of a given area depends on accurate and detailed observations over a long period. I am extremely grateful to Professor J. W. Heslop-Harrison, F.R.S., who has worked in the Birtley area for more than fifty years, for allowing me to use his field notebooks as an aid to this investigation. My thanks are also due to Messrs. W. Blythe and R. Harris who helped me to date the clay workings.

REFERENCES

ANDERSON, E., 1949, *Introgressive Hybridization.* New York.
LOUSLEY, J. E., (Editor), 1953, *The Changing Flora of Britain.* London.

A NEW HABITAT FOR OSMUNDA REGALIS L.

By P. Jane Warwick
(Botany Department, University of Birmingham)

During a visit to Lancashire in November 1956 when observations were made on a number of coal-shale tips, *Osmunda regalis* L. was found on one such area near Wigan.

Information from the literature shows that although this species was once widespread in Lancashire, it has now become almost extinct there as a natural species. More recent accounts of its localities include a report in 1933 by Green (1933) for Simonswood Moss, and by Wheldon and Wilson (1907) for Ashfield. Lacey (1954) reported that although this species was looked for in the Chorley district, it had not been found. This report would seem to cover the tip in question and reference is made to the vegetation of tips.

This new locality for *Osmunda regalis* L. seems also to be a new habitat. Clapham, Tutin and Warburg (1952), in common with other authors, describe the usual habitat as fens, bogs, and wet heaths and woods on peaty soil, but in this case, the plant was found high up on a north-facing slope on the shale. The fact that a number of plants bearing fertile as well as sterile fronds were present, suggests that the fern was well established.

The surrounding vegetation as far as could be ascertained in November, consisted of *Pteridium aquilinum*, *Deschampsia flexuosa* and *Hieracium* spp. The tipping on the site ceased in 1933, and compared with other tips of the same age the colonisation is advanced. There is, however, slightly more vegetation on the area surrounding the *Osmunda*, and investigation of this part of the tip showed it to be undergoing slow combustion, the soil being warm just below the surface. Some preliminary chemical and physical investigations were made on spoil samples from the burnt and unburnt areas to see if the burning of the spoil material made a more suitable habitat for the *Osmunda*. A rough determination of particle size showed that the ratio of particles over 0·5 mm. in diameter to those smaller than this figure was 19 : 1 in the unburnt and 15 : 5 in the burnt spoil.

The water-holding capacity was determined according to Piper (1942), which is an adaptation of a method described by Keen and Raczkowski (1921). The only difference in the determination carried out on the spoil was that only the fraction which passed through the 2-mm. sieve was used, since many of the larger