

BRITISH BIRDS

Status, habitats and conservation of the Dartford Warbler in England

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INTRODUCTION

The Dartford Warbler *Sylvia undata* is a bird of maritime western Europe reaching its northern limit in England. It is the only exclusively characteristic bird of lowland heath in southern England, and its total Palearctic range is smaller than that of any other passerine breeding in the country (Voous 1960). Its future here is tied closely with the future of its habitat and has long been regarded as perilous. Moore (1962) showed how heathland in Dorset was disappearing at an accelerating rate and argued that, of all its animals, the Dartford Warbler was the most urgently in need of conservation, while Tubbs (1963, 1967) illustrated this resident bird's extreme susceptibility to cold winter weather. Early in 1974, the Royal Society for the Protection of Birds appointed CJB to investigate aspects of the Dartford Warbler's ecology relevant to its future conservation. This paper reports the first stages of the work by describing the history, present population and distribution of the Dartford Warbler in England. Vegetational and physical characteristics of breeding territories are recorded and densities assessed in relation to habitat and size of heaths. Threats to the Dartford Warbler's future and a broad conservation prognosis are considered and discussed.

EARLY HISTORY

The Dartford Warbler was first described from two specimens shot at Bexley Heath, near Dartford, Kent, on 10th April 1773 (Pennant

1776). In considering its subsequent history in England, four things can be inferred from the literature.

1. The total distribution was once larger than at present. *The Handbook* (Witherby *et al.* 1940) described the distribution in the 1930's (old counties) as mainly Hampshire and Surrey, extending into the Isle of Wight, Dorset, Sussex, Berkshire and Wiltshire. Previous breeding records were cited for Cornwall, Devon and Suffolk with uncertainty as to whether or not it still occurred there, while breeding populations in Oxfordshire, Shropshire, Staffordshire, Kent and Middlesex had certainly ceased to exist. It is now almost confined to Dorset and Hampshire, extending in small numbers into Devon, Isle of Wight, Surrey and Sussex.

2. Numbers in any one area have always been erratic; fluctuations can certainly be detected from the literature of the last century and with more precision since then. Many authors have appreciated the effects of bad winter weather, and population crashes undoubtedly followed the severe winters of 1860/61, 1880/81, 1886/87, 1916/17, 1939/40, 1941/42, 1946/47, 1961/62 and 1962/63 (and probably others).

3. At any time and place, the bird appears to have been patchy in distribution, with some heaths densely populated and others seemingly suitable but not occupied. It thus seems as if it has rarely, if ever, had sufficient time between crashes to reach saturation of all the available heathland.

4. The species has always been associated with heathland in England and it appears that no other breeding habitats have been described. Some authors describe furze (or gorse) *Ulex* as the favoured characteristic, while others regard heather *Calluna* to be the prime essential, a discrepancy which is discussed in a later section (pages 182-184).

With the recent growth of birdwatching, the history of the Dartford Warbler can almost be quantified since the last population slump as a result of the consecutive severe winters of 1961/62 and 1962/63, which caused reductions of about 80% and 90% respectively (total 98%).

HISTORY SINCE 1960

The population was surveyed fairly thoroughly in 1960-61 (Boys 1961, Raynsford 1963, Tubbs 1963) and the effects of the severe winters of 1961/62 and 1962/63 were discussed by Tubbs, Raynsford and county bird reports. Further information during the recovery period has been published by Tubbs (1969) and county bird reports. The accuracy of previous counts, especially in Dorset, is unknown and probably not high.

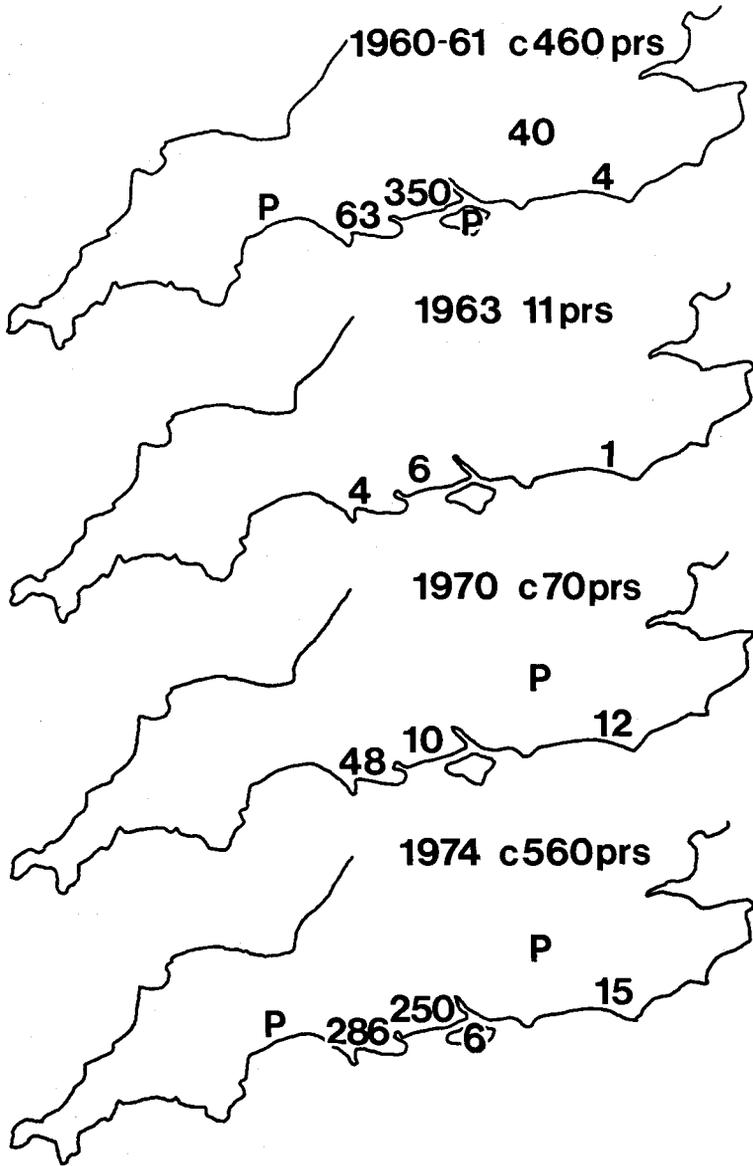


Fig. 1. Approximate numbers and distribution of breeding Dartford Warblers *Sylvia undata*. Figures represent estimated numbers of pairs in Devon, Dorset (new boundary), New Forest, Isle of Wight, north-east Hampshire and Surrey combined, and Sussex; P indicates less than five pairs. See text for sources

By 1974 it was apparent that the state of the population and its distribution were inadequately known, so an attempt at a thorough census of England was made. CJB, assisted for a period by A. Burn and P. Dolton, searched all the heathland in Dorset as well as areas of gorsy grassland, old sand pits and forestry plantations. The New Forest was surveyed by observers allocated 1 km squares to investigate. Local ornithologists in Devon, Isle of Wight, Surrey and Sussex checked most likely sites.

The numbers of territories found in each county are displayed on fig. 1 and compared with those in 1960-61, 1963 and 1970. The 1960 New Forest figure has been reduced to 350 territories from Tubbs' (1963) estimate of 382, as it is now thought to have included over-estimation by one observer. In the New Forest in 1974, 203 pairs were actually found, but two large areas thought to support about 40 pairs were not recorded at all and another area was only partially covered, so the total of 250 territories includes an element of estimation. The overall accuracy of these counts is unknown, but Dartford Warblers can be very elusive. The Dorset figure is probably no more than 90% of the real total, and the New Forest results less accurate. It is unlikely that more than a few pairs nest undetected outside the known range.

Although the total population in 1974 was similar to that at the last peak (1960-61), a marked change of distribution is apparent. The Surrey and north-east Hampshire population of at least 90 pairs in 1933 (Bond 1955) and of about 40 in 1961 has failed to re-establish itself. There have been sporadic attempts since 1968, and recolonisation looked promising in spring 1974 until fire destroyed the main site. Many of these heaths are becoming unsuitable for Dartford Warblers because of tree encroachment, but isolation from the main population is probably restricting expansion too. The small Sussex population had a short period of success, largely as a result of gorse development on a single site following a reduction of grazing after myxomatosis. Numbers are now declining at the main site, possibly as a result of the gorse becoming too old, tall and unsuitable, but as new sites are colonised the population is just holding its own. New Forest numbers took a long time to recover from the low 1963 level, perhaps in part owing to a snowfall in mid-April 1966 which caused a marked setback. This snow was less severe in coastal Sussex and Dorset sites. There appear to be still a few suitable areas in the New Forest which are not occupied, though the total area of suitable habitat has declined since 1960. Populations in Dorset, as far as they are known, have fared better, roughly doubling every two years to reach a level where they now occupy most of the seemingly suitable areas and are substantially more numerous than in 1960-61, in spite of a 40% reduction in the

heathland area in the meantime. Although the count in 1960 was probably nowhere near as thorough as the present one, several well-covered sites had many fewer pairs in 1960 than at present. The reasons for these relative changes in numbers between Dorset and the New Forest are unknown; a broadening of the habitat tolerance of the bird has been involved, though this is probably an effect rather than a cause (see next section). The Isle of Wight, surprisingly, was recolonised in 1964, but no Dartford Warblers bred in the following few years. The available habitat is very limited, and the 1974 population of about six pairs is unlikely to be much exceeded. In Devon after 1962, breeding first occurred in 1968 and has been intermittent subsequently. The heathland areas on the pebble-bed commons in the south-east are frequently burned. Further to the south and west, there are areas which appear superficially to be suitable for Dartford Warblers, some of which, especially coastal gorse thickets, enjoy a mild winter climate. A small and remote colony discovered in 1972 and continuing to the present confirms that these areas can be suitable, so it is believed that a lack of colonists is critical.

HABITATS

Physical and vegetational characteristics of 282 Dartford Warbler territories in east Dorset and of 190 in the New Forest were recorded in 1974. The vegetation within an arbitrary 30 metres of the centre of activity of the birds was considered, describing each species as dominant, abundant, present or absent. All Dorset sites were described by CJB, and those in the New Forest by voluntary helpers, so in scope and precision they are not always thoroughly comparable. The abundant and dominant categories have been combined in the present analysis, as discrimination between them was not very consistent between observers. Table 1 shows the primary vegetation characteristics of the 472 territories. These findings confirm the traditional predilection of the species for gorse (usually *Ulex europaeus* and sometimes in Dorset western gorse *U. gallii*) and an ericaceous dwarf scrub layer dominated by heather or ling *Calluna vulgaris*, with bell heather *Erica cinerea* and less frequently cross-leaved heath *E. tetralix* or, in Dorset, even Dorset heath *E. ciliaris* subdominant. No territories were without ericaceous plants, though at twelve in Dorset and four in the New Forest these were scarce and largely replaced by moor grass *Molinia caerulea* and bristle bent *Agrostis setacea* or bracken *Pteridium aquilinum* beneath dense gorse thickets. One New Forest territory, apart from an area of *Ulex/Molinia/Agrostis*, included a young forestry plantation and a bed of reed *Phragmites australis*. Although gorse/grass associations occur widely on superficial deposits on chalk and limestone in southern

Table 1. Primary vegetation characteristics of 472 territories of Dartford Warblers *Sylvia undata*, 1974

The figures are the percentages of the total falling within each category: see text for methods

Gorse <i>Ulex europaeus</i> , western gorse <i>U. gallii</i>		Ericaceous ground vegetation		Pines, mainly Scots pine <i>Pinus sylvestris</i>		
				Dom.	Pres.	Abs.
EAST DORSET (282 territories)						
Dominant	82.9	Dominant	78.6	14.2	32.8	31.6
		Present	4.3	0.7	—	3.6
		Absent	—	—	—	—
Present	6.4	Dominant	6.4	4.3	1.4	0.7
		Present	—	—	—	—
		Absent	—	—	—	—
Absent	10.7	Dominant	10.7	9.6	0.7	0.4
		Present	—	—	—	—
		Absent	—	—	—	—
NEW FOREST (190 territories)						
Dominant	75.3	Dominant	73.2	6.3	4.7	62.2
		Present	2.1	0.5	—	1.6
		Absent	—	—	—	—
Present	15.2	Dominant	15.2	4.2	5.8	5.2
		Present	—	—	—	—
		Absent	—	—	—	—
Absent	9.5	Dominant	9.5	9.0	0.5	—
		Present	—	—	—	—
		Absent	—	—	—	—

England, Dartford Warblers rarely if ever breed in such situations unless they are sufficiently acidic to give rise to heathland. The present Sussex sites are largely of this kind, with the ground vegetation predominantly grassy but not to the complete exclusion of heather. Bramble *Rubus* is also frequent at these sites, and at others in the Channel Islands (Dr C. J. Cadbury, verbally), and may be an acceptable dwarf scrub in place of heather.

In Dorset, heights of gorse and ground vegetation in each territory were assessed by a visual selection of the average which was then measured to the nearest 10 cm. These data are presented in table 2. Ground vegetation of moderate depth (median 35 cm) was most frequent, though examples were found of Dartford Warblers living in the complete range of depths which occur. The New Forest data, measured in feet, were too crude for comparison, but the impression is that ground vegetation was deeper, being over two feet (60 cm) deep in 50% of territories compared with only 8% in Dorset. It is suggested that this primarily represents difference of growth between the two areas. Raynsford (1960) reported that, even with suitable

Table 2. Average heights of ground vegetation and gorse *Ulex* in territories of Dartford Warblers *Sylvia undata* in east Dorset, 1974

Gorse (cm)	Ground vegetation (cm)									TOTALS
	10	20	30	40	50	60	70	80	90	
—	—	1	8	11	7	3	2	1	—	33
40	—	1	—	—	—	—	—	—	—	1
50	1	—	3	—	—	—	—	—	—	4
60	—	4	6	4	1	—	—	—	—	15
70	—	7	5	8	—	1	—	—	—	21
80	1	9	10	8	2	3	—	—	—	33
90	—	4	9	10	3	2	—	—	—	28
100	1	3	10	6	3	—	2	—	—	25
110	—	3	6	2	1	—	—	1	—	13
120	—	2	11	9	6	3	1	—	—	32
130	1	2	4	5	3	3	—	—	1	19
140	1	2	3	6	1	1	—	1	—	15
150	—	2	5	1	4	1	2	—	—	15
160	1	—	4	3	1	—	—	—	—	9
170	—	2	3	—	2	1	—	—	—	8
180	—	—	2	3	—	1	—	1	—	7
190	—	—	—	—	—	—	—	—	—	—
200	—	—	—	—	1	—	—	—	—	1
250	—	—	—	—	1	—	—	—	—	1
TOTALS	6	42	89	76	36	19	7	4	1	280

gorse, Dartford Warblers were absent in Surrey if heather was less than two feet high, and Moore (1975) found a similar situation in Dorset at this time. Stands of heather on Dorset heathland rarely exceed 60 cm in depth at the moment, but there are a few areas, especially where grazed, with suitable gorse and very low heather (under 20 cm) that are thinly tenanted. The New Forest has extensive areas of low, heavily grazed ground vegetation sparsely occupied by Dartford Warblers.

Height of gorse, on the other hand, seems to be selected more critically. The median height of only 104 cm in Dorset and the few territories in gorse more than 150 cm high suggest strong selection against tall stands. Gorse was commonly found in excess of 200 cm high. The factor common to most of the gorse areas occupied was a dense continuity between the ground vegetation and the gorse canopy. In view of the correlation between heights of gorse and ground vegetation (see table 2), it is suggested that it is primarily the physique of gorse which determines when a heathland area is suitable for Dartford Warblers, and the fact that the heather is normally fairly deep merely reflects the amount it has grown in the time taken for gorse to develop sufficiently following fire or cutting.

Gorse was scarce or absent in 51 of 282 (18%) Dorset territories and in 18 of 190 (9%) in the New Forest. Of these, 33 in Dorset and

17 in the New Forest were in areas dominated by pine *Pinus* and heather. A mere 15 territories in Dorset and one in the New Forest had only little pine or gorse and were predominantly heather, so this does not seem to be a major habitat at the moment. In his 1961 survey, Tubbs (1963) recorded eight pairs out of 77 from heather territories without pine or gorse. Pure heather is more widespread in the New Forest than in Dorset, and reaches greater heights in the few areas where it is not overgrazed. The pure heather territories reported in the past seem to have involved stands at least 70-100 cm deep. These are most likely to occur on the slightly richer soils in Surrey. In Dorset such depths are extremely infrequent, perhaps in part because few areas have survived unburned for long enough but also probably because of the extremely impoverished soils. In 1974 only one territory (in Dorset) lacked pine and gorse, having extensive bramble thickets with a scattering of birch *Betula*, broom *Sarothamnus scoparius*, ash *Fraxinus excelsior* and rose *Rosa*.

Of the 80 territories (51 in Dorset, 29 in the New Forest) where pine trees predominated, 76 were forestry plantations and the remaining four, all in Dorset, the result of natural regeneration. This habitat has previously been under-recorded, though diaries of B. J. Ringrose in CRT's possession confirm that it was used in the New Forest in the 1930's, and Bond (1939) described small pines a few feet above the heather as a near-essential feature and attributed the Dartford Warbler's strength in Dorset in the 1930's to the Forestry Commission's activities in planting pines. Neither Tubbs (1963) nor Moore (1975) found the birds in such areas. In Dorset in 1974 the plantations were mostly of Scots pines *P. sylvestris* and Corsican pines *P. nigra*, and occasionally of other species. Scots pines appeared to be favoured, nearby areas of exotic species sometimes not being occupied. In the New Forest, 17 territories were dominated by Scots pine but the remaining twelve contained a wide range of species, mostly in mixtures and including beech *Fagus sylvatica*, larch *Larix decidua*, Douglas fir *Pseudotsuga menziesii* and Norway spruce *Picea abies*. In Dorset the trees were mainly between eight and eleven years old; two younger sites with trees five and six years old were dominated by gorse. There were three sites with trees 12-14 years old and none with older. In the New Forest, the plantations were 10-14 years old. All, however, showed great variability of performance, with some trees over ten years old still less than a metre high (table 3). It is only the slow growth of some of the trees that allows heather to re-establish itself after the disturbance of planting and reach sufficient height for Dartford Warblers before the tree canopy closes and the site becomes unsuitable. The partial shading probably helps by drawing the heather up. Many of these areas were ploughed before planting, which might also encourage a

Table 3. Height range of young pines *Pinus* in 51 Dorset territories of Dartford Warblers *Sylvia undata* in which these were dominant, 1974

		Maximum (metres)				
		2	3	4	5	6
Minimum (metres)	< 1	1	7	7	2	—
	1	4	9	14	2	1
	2	—	—	3	1	—

dense ground vegetation: certainly in some large areas it has led to development of gorse, which favours disturbed ground.

Another unexpected feature is the presence of mature pine trees in many territories. Tubbs (1963) and Moore (1975) found their absence characteristic, though Walpole-Bond (1914) discovered Dartford Warblers in such terrain. The present survey found mature pines in 65 of 282 territories in Dorset, where savannah pine heaths (Moore 1962) are common, but in only five in the New Forest. In Dorset, there were usually one to five such trees within an arbitrary 30 metres of the centre of a territory (a density of 4-18 per hectare), and occasionally up to ten. Heights varied between five and 20 metres with a mean of 10.3 metres. Birds were seen foraging and singing in the canopies of these trees, in one case 20 metres off the ground. Moore (1962) observed that the Dartford Warbler was rarely, if ever, found near large trees, hence its absence on savannah pine heath and near the edges of plantations. This is now untrue, and indeed the two biggest concentrations in Dorset in 1974 were on areas of savannah pine heath where the birds were scarce in the previous survey. Dartford Warblers appear to inhabit areas with dense and scattered pines in France and Spain. In England, perhaps, as with other birds at the edge of their range, the habitat is normally more limited and the present high population may have encouraged spread into other areas. Small pine trees were present in territories in the New Forest and especially Dorset where, as a result of extensive plantations, there are more parent trees and more signs of pine colonisation of open heathland. Venables (1937) described Dartford Warblers actually nesting in such trees in Surrey at a time of high population.

The only other widespread scrub vegetation was birch which was present in 132 territories (only nine of them in the New Forest where it is relatively uncommon on the heaths). It was abundant in a further 15 territories in Dorset where willow *Salix* was found in 37 territories, bramble and oak *Quercus* both in 19. No other scrub species occurred in more than ten territories. Dartford Warblers were observed feeding in birch, especially on lepidopterous and hymenopterous larvae on the merging leaves in spring, so this might

be an important source of food at an otherwise lean time of year, but this is outside the scope of the present paper. The incidence of small deciduous trees, especially birch, is higher now than in 1960, when this kind of area was considered to be the typical domain of the Whitethroat *Sylvia communis* (Moore 1975). In 1974 Whitethroats were very uncommon on Dorset heaths as a result of the population crash in 1969 and their subsequent failure to recover (Winstanley *et al.* 1974). It may be that when the Whitethroat was common it prevented the Dartford Warbler from occupying these areas. This seems unlikely, as Dartford Warblers would often have been incubating by the time Whitethroats reach the country, but F. V. Blackburn (*in litt.*) has described how in two cases he has seen territory-holding Dartford Warblers apparently displaced by later-arriving Whitethroats which are substantially bigger (average weights of breeding birds about 9-10 gm and 13-14 gm respectively).

It has been suggested by Moore (1962) and several observers verbally that the Dartford Warbler favours sheltered areas and south-facing slopes for breeding, while Nethersole-Thompson (1933) and Raynsford (1960) described a preference for slopes without mentioning aspects, so the data from this survey were investigated with this in mind (table 4).

Pairs were found on slopes facing various directions, with no clear preference for any one. In Dorset, three-quarters of the territories were on slopes or undulating ground. In contrast, in the New Forest 137 of 203 territories recorded were on flat ground. These differences are probably caused by differences of topography of the heaths. Away from the New Forest, flat heaths are most prone to reclamation. Furthermore, gorse is more frequent on broken ground and valleys or banks. Thus, this analysis shows no tendency for birds to select sloping ground, but merely reflects its frequency on

Table 4. Aspects of 214 territories of Dartford Warblers *Sylvia undata* in 1974

The remaining territories were either flat or with no single aspect

	DORSET			NEW FOREST Totals	GRAND TOTALS
	Flat slope	Broken slope	Valley		
N	13	8	2	0	23
NE	10	4	1	3	18
E	13	3	1	10	27
SE	13	10	5	5	33
S	19	6	4	18	47
SW	10	4	1	2	17
W	5	5	1	10	21
NW	11	7	2	8	28
TOTALS	94	47	17	56	214

the areas under study. As the same time it may be that, in the exposed heathland environment, birds are selecting shelter or other desirable micro-climates too subtle for detection by this crude investigation. This might especially be true in winter.

DENSITY AND TERRITORY SIZE

Densities of Dartford Warblers are difficult to calculate because there are few areas where suitable habitat is extensive. On most dry, heather-dominated heaths, gorse occurs only in patches often along old tracks, field systems and boundaries, or in valleys (Jones and Tubbs 1963), so any measurement of the area available to Dartford Warblers is arbitrary. However, Tubbs (1974) calculated the area of *Ulex europaeus* associated with deep heather in the New Forest as 1,226 acres (496.2 ha). This excluded forestry plantations and manorial wastes adjoining the Forest, both of which were covered by the 1974 Dartford Warbler survey. Taking this into account there were, in 1974, 160 pairs of Dartford Warblers on 496.2 ha of habitat, giving a mean density of 3.1 ha per pair or 32.2 pairs per square kilometre.

Table 5 records observed densities calculated in two different ways. The upper half of the table includes all Dorset sites with more than ten pairs on a single fragment of heath, but the total areas include obviously unsuitable habitat such as boggy or recently burned ground. The lower half shows densities in those places where a concentration of Dartford Warblers was found, from measurement of the actual area occupied by the birds. Thus, in the rare places where good habitat is extensive, densities of 30-70 pairs per sq km occur, but in practice suitable habitat is very fragmented and densities of 10-20 pairs per sq km are more typical for an area of dry heathland. The densities in pine plantations were similar to those found on gorse and heather habitats.

Because of the difficulty of assessing densities by such a method, another was tried. For each pair in Dorset, the distance of its centre of activity from that of its nearest neighbour was measured from a map if there was continuous dry heathland between them (table 6). No pairs less than 70 metres apart were found and the average separation was 166 metres. If birds were uniformly spaced at this separation, this would give a territory size of 2.38 ha or a density of 42 pairs per sq km. This figure agrees closely with the maximum densities actually found in the few places of uniformly suitable habitat shown in table 5.

Previous estimates of Dartford Warbler densities are few. Venables (1934) gave 19.6 pairs per sq km (5.1 ha per pair) on the best area of a Surrey heath where many pairs were evidently nesting in pure heather. Blondel (1969) found about 5 ha per pair in a good year

Table 5. Densities of Dartford Warblers *Sylvia undata* in 1974

The upper part covers all heaths in Dorset with more than ten pairs on a single fragment; the areas of these fragments include bog and burned ground. The lower part considers only marked concentrations of Dartford Warblers in areas of continuous apparently suitable habitat

	Site	Area (ha)	Pairs	ha/pair	prs/km ²	Features
DORSET	A	235	12	19.6	5.1	some bog
	B	270	18	15.0	6.7	much bog
	C	407	25	16.3	6.1	bog and recent fire
	D	219	14	15.6	6.4	much bog
	E	171	20	8.6	11.7	bog and recent fire
	F	386	31	12.5	8.0	much bog
	G	129	28	4.6	21.7	mainly dry heath
DORSET	C	39	17	2.3	43.6	} dry heath with <i>Ulex</i>
	F	29	21	1.4	72.4	
	G	53	27	2.0	50.9	} forestry plantation
	H	43	13	3.3	30.2	
	J	16	8	2.0	50.0	
	K	28	8	3.5	28.6	
NEW FOREST	L	34	15	2.3	44.1	} dry heath with <i>Ulex</i>
	M	34	10	3.4	29.4	
	N	20	6	3.3	30.0	
	O	19	9	2.1	47.4	
	P	32	11	2.9	34.4	} forestry plantation
	Q	18	6	3.0	33.3	
	R	28	10	2.8	35.7	
TOTALS		288	124	2.3	43.1	dry heath with <i>Ulex</i>
		105	37	2.8	35.2	forestry plantation

Table 6. Distance of each pair of Dartford Warblers *Sylvia undata* from its nearest neighbour for all territories where there was continuous heathland between them

See text for method of calculation. The mean separation was 166 metres

metres	pairs	metres	pairs	metres	pairs
70	8	170	8	270	4
80	20	180	17	280	—
90	14	190	10	290	4
100	16	200	2	300	3
110	7	210	15	310	3
120	6	220	6	320	4
130	22	230	5	330	—
140	12	240	10	340	1
150	6	250	5	350	4
160	9	260	2		

on a southern French *garrigue* where there was possibly competition from Sardinian Warblers *S. melanocephala* and Subalpine Warblers *S. cantillans*. On a 10-ha heath in Brittany, Constant and Maheo (1970) found four pairs in two successive years. Thus the best areas in England in 1974 had higher densities of Dartford Warblers than previously recorded, but for most areas the figures compare with those from elsewhere. Other *Sylvia* species in north and central Europe appear to occupy smaller territories, often less than 1.0 ha. From data collected in 1971 for the British Trust for Ornithology at Northward Hill, Kent, the following territory sizes were estimated: Garden Warbler *S. borin*, 1.04 ha (13 territories); Lesser White-throat *S. curruca*, 1.02 ha (6); Blackcap *S. atricapilla*, 0.51 ha (35); and Whitethroat, 0.50 ha (25) (see also, e.g., Raines 1945, Siefke 1962, Diesselhorst 1968, Persson 1971). On the other hand, the very similar Marmora's Warbler *S. sarda*, which largely replaces the Dartford geographically in the western Mediterranean islands, was found to occur at 15 pairs per sq km in Formentera, though an analysis of distance between neighbouring nests gave 25 pairs per sq km (Berthold and Berthold 1973).

Both Moore and Tubbs have suggested that fragmentation of the habitat available to Dartford Warblers (and other heathland creatures) may have a deleterious effect over and above the direct loss of total area. No detailed evidence to support such a contention had been published, so a further analysis of the 1974 distribution of Dartford Warblers was made. The areas of all separate fragments of heathland in Dorset were measured from a 1:25,000 map to the nearest 0.1 ha using an electronic digitiser and integrating program. Areas divided by only a road were considered as one. In practice some of the smaller areas were separated from or united with the parent site somewhat arbitrarily when the ground between was partially destroyed heath, but separation of the larger sites was generally clear. No attempt was made to measure areas considered suitable for Dartford Warblers, on the assumption that, as already mentioned, this would not have been easy, and in addition would partially beg the answer to the question under investigation.

Table 7 sets out the size distribution of sites in Dorset and the numbers of Dartford Warblers occupying them. A trend of increasing density of birds with increasing size of site is apparent, though the three largest sites formed an unfortunate sample because one is a tank firing range, much burned and churned up, the second is a development site also much burned, and only one is mature heath, though that too suffered a major fire in 1974 (but had 39 of the 47 pairs involved). Nevertheless, without making allowance for this fact, the densities on the 63 smaller sites (64 ha or less) were compared with those on the rest by a chi-squared test and found to be

Table 7. Distribution of Dartford Warblers *Sylvia undata* in relation to size of sites

All heathland sites in Dorset are included whether or not they were occupied by or even suitable for Dartford Warblers

Area (ha)	Number of sites	Total area (ha)	Pairs	Prs/km ²
0 - 32	46	548.2	14	2.6
32.1- 64	17	717.2	20	2.8
64.1- 128	7	654.4	21	3.2
128.1- 256	10	1,804.0	108	6.0
256.1- 512	2	655.5	50	7.6
512.1-1,024	3	1,802.2	47	2.6
TOTALS	85	6,181.5	260	4.2

significantly lower ($p < 0.01$). Thus fragmentation of heathland is in its own right undesirable for Dartford Warblers (and probably other creatures too) and, by converse, conservationists should concentrate their efforts on the larger sites. In addition to possible delays in recolonisation, and the reduced chances of all the required elements of suitable habitat being available, small sites often show changes of conditions as a result of enlarged edge effects. The most notable of these are nutrient enrichment from adjoining farmland and grazing by Rabbits *Oryctolagus cuniculus* which rarely penetrate far on to a heath. Both have a profound effect on the vegetation; heather especially is rapidly replaced by grasses on such sites.

DISCUSSION AND CONSERVATION PROGNOSIS

The Dartford Warbler is on the edge of its range in Britain and, though once more widespread in south and central England, was probably never very numerous. At the same time it is exceptionally susceptible to bad winter weather which is sufficiently frequent to ensure that numbers rarely, if ever, reach the holding capacity of the available habitat. These facts might lead some to dispute the value of devoting any conservation effort to it at all. Though valid, the reasons for conserving a bird species on the edge of its range are perhaps esoteric (see, e.g., Drury 1974). Lowland heath is, however, a special ecotope of very limited distribution, with a wealth of characteristic species and much in need of conservation (see Moore 1962 and Gimingham 1972 for further discussion). Soundly based consideration of its special vertebrate predators, such as the Dartford Warbler or the Sand Lizard *Lacerta agilis*, is a promising approach to the conservation of lowland heath in so far as their requirements are extensive. Lower animals or plants will survive within such a framework with only minor modifications for their special requirements.

Apart from the risk of extermination by bad weather, the future of the Dartford Warbler in England is threatened by three factors: direct interference, disappearance of heathland, and ecological changes on remaining heaths. These are discussed in order of increasing importance.

The species has long been a target of egg-collectors. Nethersole-Thompson (1933) described its special appeal, while a recent note (Blair 1965) confirms that the Dartford Warbler still has interest to the egg-collector. Any information on the effects of collecting is difficult to find now that it is illegal, but Bibby (1973) found it to be a contributory factor, locally speeding the decline of the Red-backed Shrike *Lanius collurio* in England. Collecting, particularly after a population crash, could be very damaging to the Dartford Warbler. Birdwatchers too might be a hazard at such times, as they come in large numbers and often with little consideration.

Loss of heaths to agriculture, forestry, urbanisation and mineral extraction is continuing apace in Dorset: 30,000 ha of heath at the end of the last century had declined to 10,000 by 1960 (Moore 1962) and has fallen further to about 6,000 at present (this survey and Rippey 1973). Agricultural reclamation is not irreversible and farmland abandoned in the recession at the end of the 19th century reverted to heath (Kerr 1968). It is, however, difficult to imagine such a reversal happening again. The human population of south-east Dorset may increase by as much as 44% before the end of the century, requiring the development of up to 7,200 ha of land (Dorset County Council 1974), and building activity is constantly encroaching on heathland, much of which adjoins the Poole-Bournemouth conurbation. Four heaths are nature reserves, but all on short leases. Three areas of Ministry of Defence land, containing about 1,160 ha of heath, have long-term chances of survival but are in a poor state as a result of military use. The future of the remaining fragments in Dorset is questionable and some are certainly destined for development of various kinds. The future of the heaths of the New Forest, north-east Hampshire and Surrey is more secure. The 14,500 ha of heathland in the New Forest are statutorily protected against reclamation and development. In north-east Hampshire and Surrey, processes of heathland reduction and fragmentation similar to those in Dorset have left isolated areas owned by the National Trust, Ministry of Defence and nature conservation organisations. However, both in the New Forest and on the north-east Hampshire and Surrey heaths, ecological changes are occurring which may alter them fundamentally.

It is important to remember that heathland has arisen from the clearance of an early woodland by man and his animals and that it is maintained by a combination of factors, the most important

of which are grazing and burning. In the absence of one or both of these, heaths tend to revert to woodland, often through a pioneer birch or pine stage. This process is most conspicuous in Surrey where large open expanses dominated by heather have changed to heathland fragments broken by extensive mixed woodland in the course of the last 40 years. Birch appears to be a successful colonist in the wake of fires, and the woodland succession of the Surrey heaths is probably aided by the high human usage and less than adequate fire precautions. Although the establishment of fire rides and the manual removal of saplings will slow up the succession, the long-term maintenance of the heaths in north-east Hampshire and Surrey would probably be more secure if controlled grazing could be re-established: there are plenty of ponies in prosperous Surrey! In Dorset, similar changes can be seen locally but they are occurring more slowly, probably because the soil is poorer; Scots pine is the more prominent colonist.

In contrast to the virtually ungrazed lowland heaths elsewhere, the New Forest is overgrazed. Densities of cattle and ponies on the unenclosed Forest are as high today as at any previous period for which records exist (Tubbs unpublished, *Lymington Times* 12.ii.75). In many areas the vegetation is heavily suppressed by grazing and trampling. The heaths are subject to periodic burning, albeit carefully planned and controlled, and gorse starting to regenerate after fire is often killed by browsing because the fresh shoots are especially palatable. At the same time, mature stands of gorse are used by the animals for both forage and shelter and are often heavily trampled and broken open as a result. Much of the ground vegetation is short because of trampling and grazing; and moor grass and, to a lesser extent, bristle bent are abundant by comparison with the ungrazed Dorset heaths. The main object of controlled burning in the New Forest is to provide a fresh flush of vegetation for the benefit of the commoners' animals, but the benefits are often dubious and the practice difficult to justify when balanced against the reduced diversity of the habitat (for both wildlife and the stock) resulting from a combination of burning and heavy grazing (Tubbs 1974). Burning undoubtedly encourages the spread of bracken on drier sites at the expense of the heather. The predominance of bracken on the Welsh hills and parts of Dartmoor has been attributed to over-zealous pasture improvement, especially by fire (see, e.g., Ward *et al.* 1972), and this process can be seen in both the New Forest and Surrey. It has been suggested that burning of mature heathland vegetation in the New Forest has reduced the Sand Lizard from 22 known sites to extinction in the past two decades (Prestit *et al.* 1974).

This régime has clearly influenced the Dartford Warbler by direct

removal of habitat. Tubbs (1974) found 94.4 ha of gorse which had been burned and, because of browsing, failed to regenerate between 1967 and 1972/73. Thus, more than 200 ha of habitat suitable for perhaps 100 pairs of warblers has probably vanished since 1960 from this cause alone. Although the New Forest has about four times the dry heathland area of Dorset, its condition is such that it holds fewer Dartford Warblers. There is probably a small amount of vacant habitat in the New Forest, so the holding capacities of the two areas may be about equal at the moment. Adjustments to the burning régime and stocking rates of the Forest are certainly desirable in the interests of conservation (though the latter is presently not legally possible). For the Dartford Warbler's future in England, Dorset may now be the main hope by virtue of its milder winters and greater security from ecological change.

Mention should also be made of the more direct effects of humans on heathland. Trampling is probably exaggerated as a hazard because, although heather is very susceptible to it and eroded tracks look unsightly, people tend to stay on the paths and the damage is fairly limited. Dartford Warblers happily co-exist with the thousands of people who visit the Studland National Nature Reserve, Dorset, each year. A more serious physical effect is caused by military operations which involve large areas of Surrey and Dorset: the ground is not only frequently burned but often denuded of vegetation by vehicles. Such areas would rapidly recover as heaths if given the chance, so it is to be hoped that the Ministry of Defence, as a major owner of heathland which at least is safe from development, will in time become a major holder of Dartford Warblers and other heathland specialities by considerate management of its land.

If appropriate action is taken to ensure that some large areas of heath survive and these are managed in such a way as to maintain an appropriate level of grazing, burning and cutting of invading trees, the Dartford Warbler will have a moderate chance of surviving as a British breeding bird. As there is clearly an optimum density at which it can occur, the population will continue to decrease as the remaining heathland shrinks. Although there are signs of a widening of its habitat tolerance at high population levels, it is doubtful if this will continue much further than at present. The possible risk of extermination by a single cold winter is now high and will increase as the birds become more concentrated in the few remaining sites. While the controversial suggestion of Campbell (1975) of maintaining some birds in captivity for the winter merits critical appraisal, vegetation management aimed to promote winter survival in citadel areas seems to be a more satisfactory precaution to take, and research to identify a realistic strategy is

continuing. Although there are signs of the species occupying atypical habitats, these are mainly transient stages of woodland development on heaths, and are not likely to ensure that there will always be suitable habitat for the Dartford Warbler in England.

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SUMMARY

Early stages of the Royal Society for the Protection of Birds' investigation into the ecology of the Dartford Warbler *Sylvia undata* in England are reported. Examination of its history shows it has always been erratic in numbers and patchy in distribution. It is very susceptible to cold winters, but the present population is high after a long run of mild winter weather. About 560 pairs were located in 1974, compared with a previous peak of about 460 in 1960-61, and the centre of the distribution is now further west. Habitats are described in detail: mature heather *Calluna* with a generous mixture of gorse *Ulex* of medium height is preferred. Many pairs occupied pine plantations and heathland sites with scattered tall trees, both infrequently described habitats in England. No preference of aspect was found. The mean territory size was estimated at 2.38 ha, but such densities (42 pairs per sq km) were found only locally; suitable habitat is thin. spread on dry heathland and densities of 10-20 pairs per sq km were more usually found. Small fragments of heath were found to be less densely occupied than large ones.

The Dartford Warbler's future here is precarious, but its conservation is important because it is characteristic of a habitat for which England has an international responsibility. Sites are disappearing fast and fundamental changes are taking place on those that remain. It is essential to understand and control these and to learn more, particularly of the feeding ecology and winter mortality of the Dartford Warbler, to assemble a realistic conservation plan. Work is continuing.

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