The distribution and identification of earthstars (Fungi: Geastraceae) in Norfolk

Tony Leech, Trevor Dove & Jonathan Revett

All of the 18 species of earthstar recorded in Britain occur, or have occurred, in Norfolk. This may be due to the fact that many of them prefer the light sandy soils found widely in the county, but it is an accepted fact that the known distributions of fungi reflect the distribution of those who study them and Norfolk has generated many mycologists with an interest in these striking fungi.

The county's first claim to earthstar fame may well have been the discovery of *Myriostoma coliforme* near Bungay in 1782. The fact that, nearly one hundred years later, every one of the nine species of earthstar recorded by CB Plowright in his list of Norfolk fungi (1872-3) was illustrated, but only four of the remaining 800 species of fungi were so favoured, gives some indication of his fascination with the earthstars.

GJCooke in that part of his Norfolk county list of fungi dealing with gasteromycetes (1937) adds just one further species, the now widespread *Geastrum triplex*, although a number of others had occurred unknown to him. By this time EA (Ted) Ellis had begun recording and is indeed credited by Cooke for his help in indexing the older records. Ellis subsequently added *G. minimum* to the Norfolk list and published a thorough account of early records (Ellis 1981). Only one species (*G. campestre*) has been added since then and the present paper seeks to update that of Ellis with the addition of more recent records; appropriately in the centenary year of his birth. We are pleased to be able to reproduce the drawings by Ted Ellis (and his brother Martin) that illustrated his 1981 paper as Figures 1, 2 and 3.

The nature of earthstars

Earthstars are essentially puffballs in which the outer layer of the fungus fruit body splits radially into segments that open outwards and which may bend downwards to separate the fruit body from its subterranean mycelium. The resulting star-shape is eye-catching and distinctive; Plowright wrote that 'the sight [of *Myriostoma coliforme*] would gladden the heart of the most lethargic fungologist' (1872). They are often, however, surprisingly difficult to find as their muted colours blend into the background. Set against this, to the benefit of the earthstar hunter, most of the fruit bodies dry naturally and can be found well after they have emerged.

Sixteen of the British earthstars belong to the genus *Geastrum* (earlier spelled *Geaster*), a Latin 'translation' of earth star. *Myriostoma coliforme* belongs to the same family (Geastraceae) but the remaining species, *Astraeus hygrometricus*, is more closely related to the earthballs and is placed in the Astraeaceae. All belong to what were formerly the Gasteromycetes but are now better referred to as gasteroid fungi since members of the group are not closely related to each other. In gasteroid fungi spores are produced on basidia (as in other basidiomycetes) but are not actively discharged. Moreover, in earthstars, as in most gasteroid fungi, the fertile surface remains enclosed within the fruit body during development.

Earthstar fruit bodies develop as spherical or onion-shaped objects at, or just below, the soil surface. As they mature the outer layers, forming the exoperidium, split and turn downwards to reveal the endoperidium, the layer which forms the endoperidial body (or spore-sac). In some species, the 'arms' formed as the exoperidium splits are

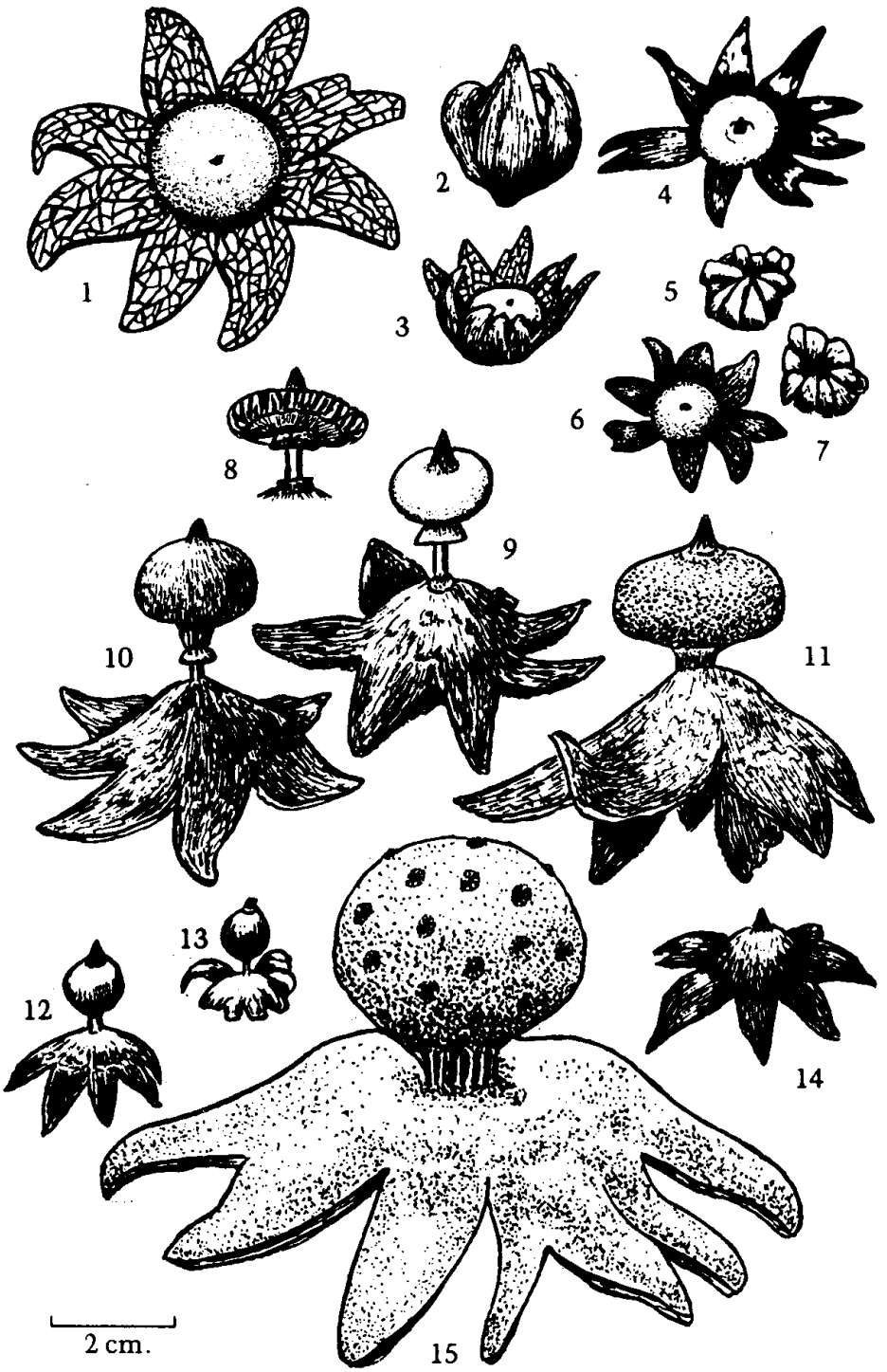


Figure 1. Earthstar fruit bodies (1). 1,2,3 *Astraeus hygrometricus.* 4,5 *Geastrum corollinum*. 6,7 *G. floriforme*. 8,9 *G. striatum*. 10 *G. pectinatum*. 11 *G. berkeleyi*. 12 *G. schmidelii.* 13 *G. minimum*. 14 *G. elegans*. 15 *Myriostoma coliforme.* Nomenclature updated. Drawn by E.A. Ellis (1981).

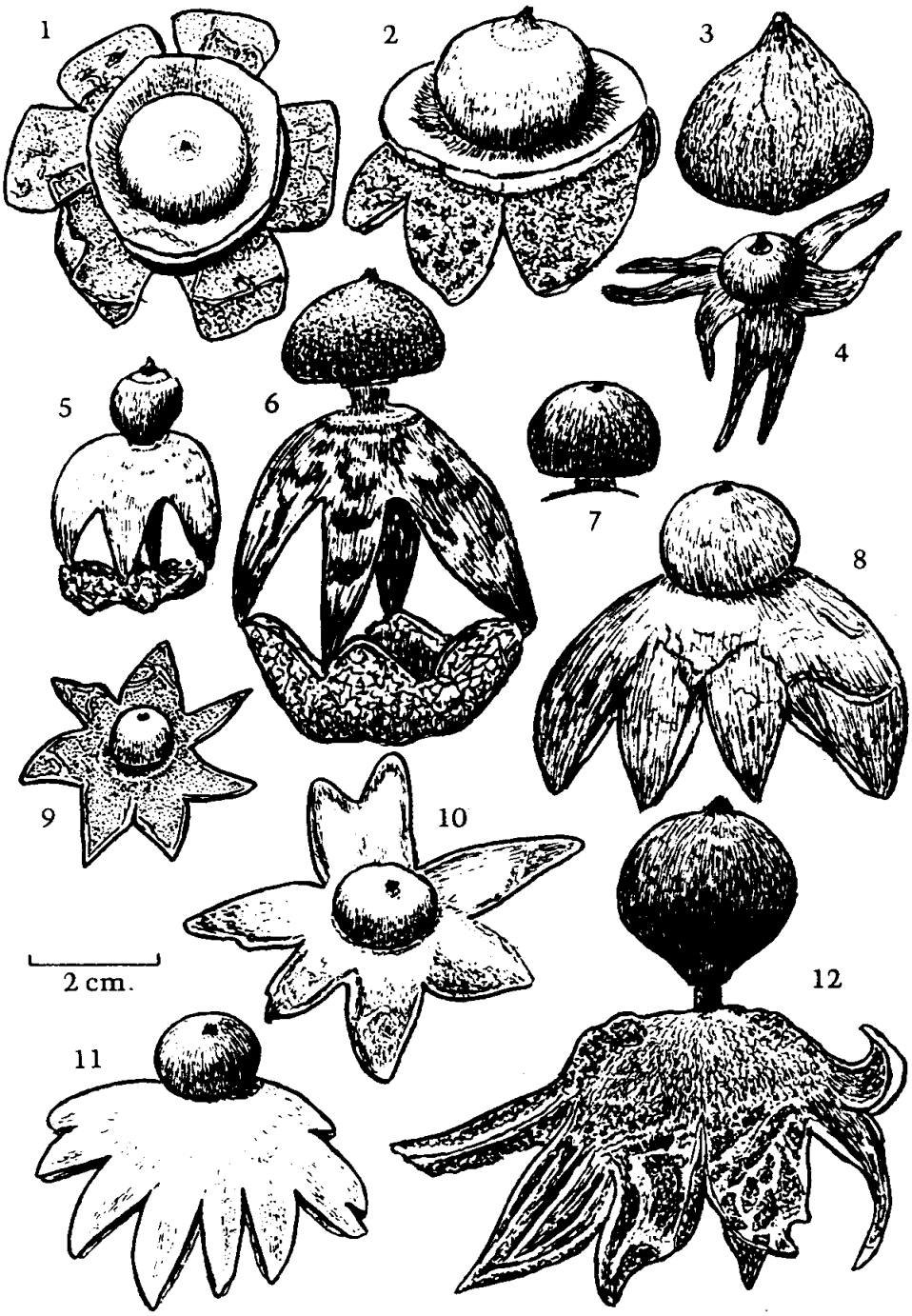


Figure 2. Earthstar fruit bodies (2). 1,2,3 *Geastrum triplex*. 4 *G. lageniforme*. 5 *G. quadrifidum*. 6 *G. fornicatum*. 7,8 *G. rufescens*. 9,10 *G. fimbriatum*. 11,12 *G. coronatum*. Nomenclature updated. Drawn by E.A. Ellis (1981).

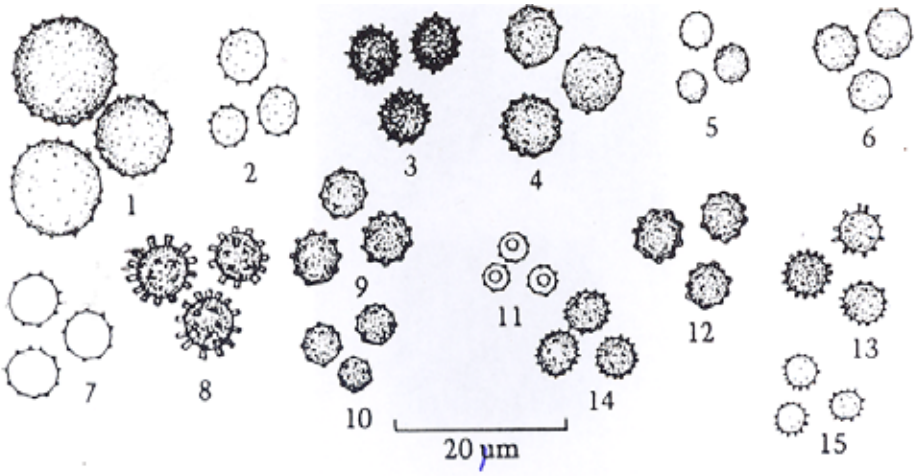


Figure 3. Earthstar spores. 1 *Astraeus hygrometricus*. 2 *Geastrum elegans.* 3 *G. coronatum.* 4 *G. floriforme.* 5 *G. fornicatum*. 6 *G. minimum*. 7 *G. schmidelii.* 8 *G. pectinatum*. 9 *G. quadrifidum.* 10 *G. corollinum*. 11 *G. fimbriatum*. 12 *G. striatum*. 13 *G. triplex.* 14 *G. rufescens*. 15 *G. lageniforme.* Nomenclature updated. Drawn by M.B. Ellis (Ellis 1981).

hygroscopic, that is, when dry they close round the spore-sac but in damp weather the rays open out and become recurved. In members of the genus *Geastrum* a central pore, surrounded by a conical peristome, allows the mature spores to escape. Features of the peristome, whether plicate (pleated), or fibrillose (fibrous) and fimbriate (fringed), are important characters for the separation of species, as is the presence or absence of a clear boundary (peristome delimited or not) around this feature. In *M. coliforme* there are several pores which, although slightly fringed, lack a true peristome. In *A. hygrometricus* the spores escape through an irregular tear in the endoperidium. Some of these features are illustrated in Figure 4.

The changes which take place during the development of an earthstar can be interpreted as adaptations to spore dispersal. The peeling back of the thick exoperidium reveals the thin-walled spore-sac which is readily disturbed by, for example, rain drops, falling debris or animals, to release the spores. Any elevation of the spore-sac will assist dispersal as the spores are more likely to be released into faster moving air and are more likely to clear surrounding obstacles. The development of a stalk and the reflexing of the rays both serve to elevate the spore-sac. In two species (*G. fornicatum* and *G. quadrifidum*) the mycelial layer under the rays splits off and pushes downwards to

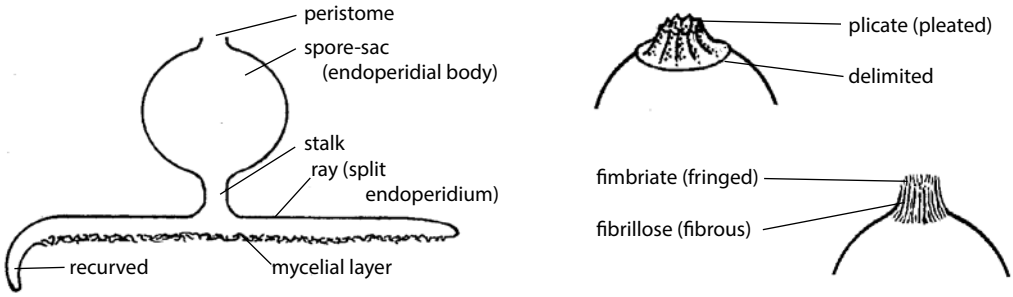


Figure 4. Terms used to describe earthstar fruit bodies.

raise the spore-sac even higher.

Identification

In common with almost all other groups of fungi, earthstars cannot usually be unambiguously identified from photographs of the entire fruit body because of variation in their overall appearance. Nevertheless, references to photographs in some of the more accessible and comprehensive fieldguides are given in Table 1, together with some of the synonyms used in the literature on Norfolk earthstars. Photographs of most species are to be found between pages 16 and 17. If attention is directed towards certain critical features and it is possible to identify normal specimens of all species without the need for microscopic examination. A dichotomous key is the usual means of achieving this and the one in Pegler *et al*. (1995) works well. An alternative approach is to tabulate these features (Table 2) and to assign letters for 'present' or 'absent' characters so that each species can be described by a code of up to seven letters (Table 1). It may be possible to gain support for a putative identification by comparing the dimensions of the specimens with the ranges given in Figures 4-7. These tables and figures are based on information in Pegler *et al.* (1995). If a microscope is available, spore size and structure may provide confirmatory evidence (Figure 8). It should be noted, however, that occasionally specimens will be found which have abnormal features, for example *G. minimum* occasionally lacks a stalk and young *G. triplex* lack the collar.

The standard reference work on this group

Table 1. Synonyms, code assignments (from Table 1) and sources of illustrations.

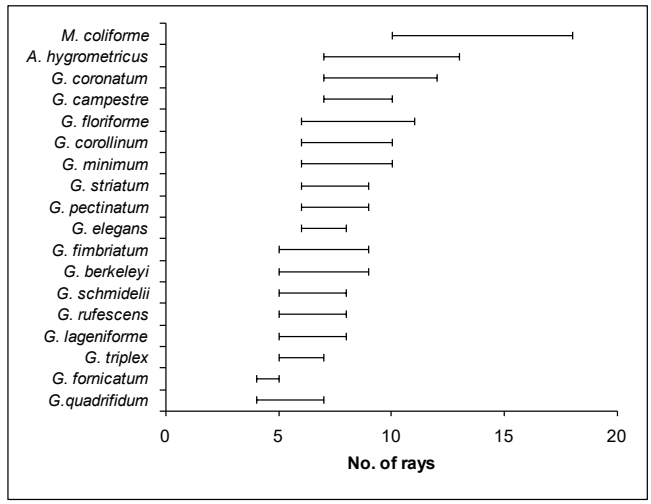
Name	Synonym	Code letters in Table 2	Illustrations			
			Phillips		Jordan 1995	Sterry & Hughes 2009
			1981	2005		
Astraeus hygrometricus (Pers.) Morgan			p.254	p.336	p.365	p279
Geastrum berkeleyi Massee		ABD [2]				
Geastrum campestre Morgan		ABDE				p.273
Geastrum corollinum (Batsch) Hollós	*G. recolligens*	CDE				
Geastrum coronatum Pers.		ACF	p.253	p.336	p.359	
Geastrum elegans Vittad.	*G. badium*	BD				
Geastrum fimbriatum Fr.	*G. sessile*	C	p.252	p.334	p.359	p.271
Geastrum floriforme Vittad.		CG				p.271
Geastrum fornicatum (Huds.) Hook.		AC(D)FG [3]	p.254	p.334	p.359	p.271
Geastrum lageniforme Vittad.	*G. saccatum*[4]	CD [5]				
Geastrum minimum Schwein.		ACDF				p.341
Geastrum pectinatum Pers.		ABD [2]	p.254	p.336	p.360	p.273
Geastrum quadrifidum Pers.		ACDFG [3]	p.253	p.335	p.360	p.271
Geastrum rufescens Pers.	*G. vulgatum*	ACF	p.253	p.335	p.360	p.271
Geastrum schmidelii Vittad.	*G. nanum*	ABD [2]	p.253	p.336	p.361	p.341
Geastrum striatum DC.		ABD [2]			p.361	p.273
Geastrum triplex Jungh.		CD [5]	p.253	p.335	p.361	p.271
Myriostoma coliforme (With.: Pers.) Corda			p.252	p.334	p.362	p.339

Table 2. Identification features of earthstar species.

Species	Spore-sac		Peristome (mouth)			Rays		Mycelial layer		Other features
	Stalked	Surface[1]	Grooved	Fibrous and fringed	Delimited[2]	Hygroscopic[3]	Recurved[4]	Sticks to debris	Separates downwards	
Code letter (see Table 2)	**A**		**B**	**C**	**D**	**E**		**F**	**G**	
Astraeus hygrometricus	×	felty	irregular opening			✓	×	(✓)	×	reticulate pattern on rays
Geastrum berkeleyi	✓	finely warty	✓	×	✓	×	×	×	×	
Geastrum campestre	✓	finely warty (smooth)	✓	×	✓	✓	✓damp	×	×	
Geastrum corollinum	×	smooth (powdery)	×	✓	✓	✓	✓damp	×	×	
Geastrum coronatum	✓	almost smooth	×	✓	occ	×	(✓)	✓	×	
Geastrum elegans	×	smooth (powdery)	✓	×	✓	×	✓	×	×	
Geastrum fimbriatum	×	minutely downy	×	✓	×	×	✓	×	×	
Geastrum floriforme	×	scurfy	×	✓	×	✓	✓damp	×	×	
Geastrum fornicatum	✓	finely hairy	×	✓	(×)	×	×	✓	✓	ray margins incurved
Geastrum lageniforme	×	minutely downy to smooth	×	✓	✓	×	(✓)	×	×	
Geastrum minimum	✓	(powdery)	×	✓	✓	×	(✓)	✓	×	
Geastrum pectinatum	✓	smooth (powdery)	✓	×	✓	×	(✓)	×	×	
Geastrum quadrifidum	✓	powdery	×	✓	✓	×	×	✓	✓	
Geastrum rufescens	✓	minutely downy	×	✓	×	×	(✓)	✓	×	rays slightly pinkish
Geastrum schmidelii	✓	smooth	✓	×	✓	×	(✓)	×	×	
Geastrum striatum	✓	finely striate when rubbed	✓	×	✓	×	(✓)	×	×	spore-sac with basal collar
Geastrum triplex	×	smooth	×	✓	✓	×	(✓)	×	×	fleshy collar around spore-sac
Myriostoma coliforme	✓	warty and pitted	many openings			×	(✓)	✓	×	

Features in brackets are less reliable. **Note 1** Spore-sac surface tends to loses features and becomes smoother with age. **Note 2** Distinct zone around peristome; can be surrounded by a ridge. **Note 3** When dry, rays close round spore-sac; when damp, rays open out. **Note 4** As an earthstar ages, arms are more likely to recurve.

Figure 4. Ranges of earthstar ray numbers.



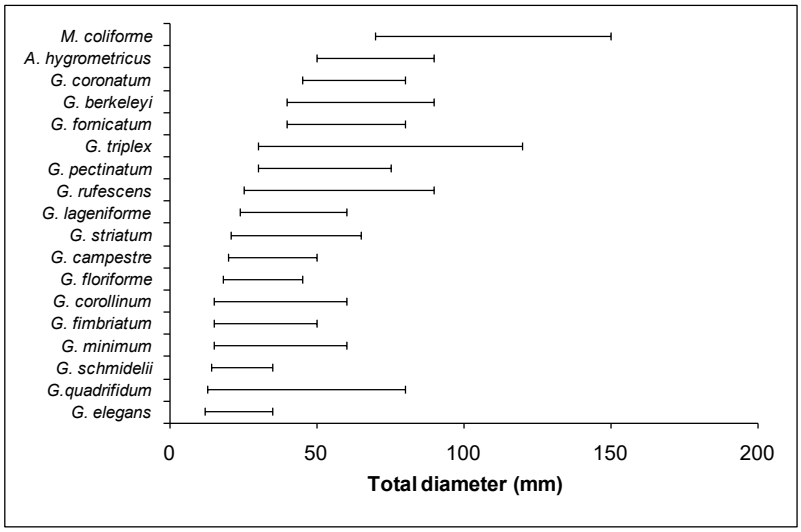
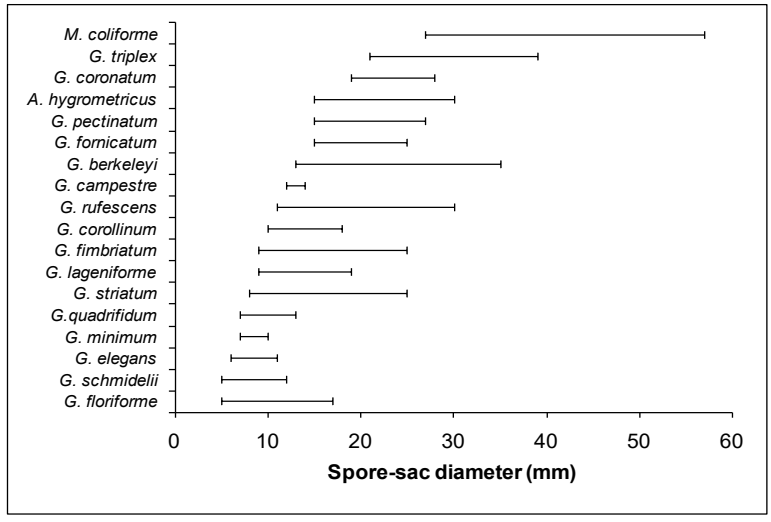


Figure 5. Ranges of earthstar total diameters.

Figure 6. Ranges of earthstar spore-sac diameters.



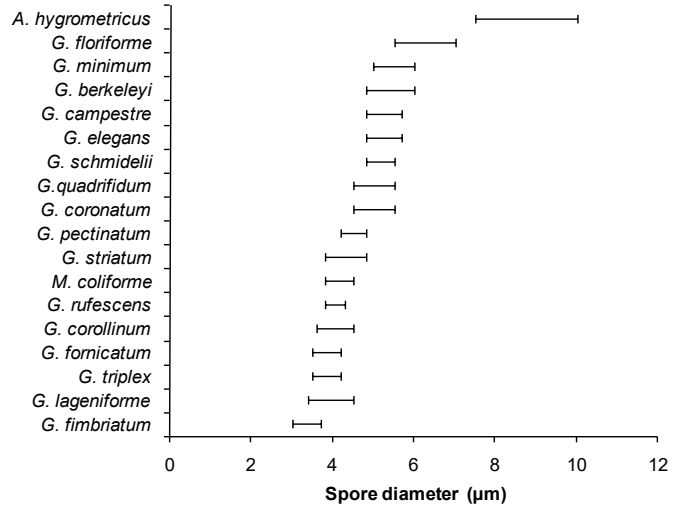


Figure 7. Ranges of earthstar spore diameters.

is Sunhede (1989) but for British species the monograph on the gasteroid fungi by Pegler *et al.* (1995) is considered authoritative.

Distribution

Most of the early Norfolk records are taken from Ellis (1981) or the Fungus Record Database of the British Isles (FRDBI) maintained by the British Mycological Society and accessible at http://www.fieldmycology.net. Recent Norfolk records are from Richard Shotbolt's Norfolk Fungus Database which is held at the Norfolk Biodiversity Information Service, or have been supplied by personal communication. Information about national distributions is from Pegler *et al.* (1995) or the FRDBI.

Grid references in the form, ~TG 0434 are given as an approximate indication of location but were not supplied with the original record. They were obtained from Driscoll & Hewitt (1999) and refer to the 1 km square in which the initial letter of the place name appears on the Ordnance Survey 1:25000 First Series maps. A plus sign after a year (e.g. 2000+) indicates that the fungus was seen in the same location at some time during the succeeding five years. Where known, the

Table 3. Full names of recorders referred to in Tables 4-9.

Initials	Name	Initials	Name	Initials	Name
ALB	AL Bull	GJC	GJ Cooke	RGB	RG Betts
ARD	AR Disney	GM	G Massee	RHS	RH Sewell
BI	B Ing	HLJ	H Lindley Jones	RJC	RJ Colman
(BMS)	Brit. Mycological Soc.	HW	H Williamson	RK	R Key
CAB	CA Blenkiron	JJR	JJ Revett	RMSB	RMS Brown
CB	C Bryant	JML	JM Lambert	RPBO	RP Bagnall-Oakeley
CBP	CB Plowright	JP	J Palmer	RWT	RW Turner
CPP	CP Petch	JS	J Sowerby	THP	T Hyde Parker
CR	C Rea	KT	K Trimmer	TJW	TJ Woodward
DAB	DA Boardman	MN	M Nichols	TWD	TW Dove
EAE	EA Ellis	MP	M Pett	WEHF	WEH Fiddian
EM	E Mountford	MW	M Wright		
GCHC	GCH Chandler	REE	RE Evans		

Table 4. Records of *Geastrum corollinum*.

Year	Place	Grid	Name	Year	Place	Grid	Name
1782			CB	1896+	Hillington	~TF 7125	CBP
1794	Earsham	~TM 3289	TJW	1938	Hellesdon	~TG 2010	HLJ
1794	Ditchingham	~TM 3292	TJW	1983	Wortwell	TM 2080	EAE
1861	Crostwick	~TG 2515	KT	2006	Edgefield	TG 0934	TWD

names of identifiers take precedence over finders and finders over reporters. The full names of those responsible for records are given in Table 3.

Astraeus hygrometricus Barometer Earthstar

This large and distinctive earthstar was first recorded in Norfolk by the Rev. K. Trimmer in 1866 from a sandy bank at Rackheath (~TG 2714). Trimmer never published his records but made them available to C.B. Plowright who did (beginning in 1872). The second find was from King's Lynn (~TF 6218) in 1897 (reported by C Rae) and the third was by CP Petch in December 1927 from Holt (~TG 0838). Some sixty years later M.A. Brewster found it near Saxthorpe (TG 1131), where a small colony was observed along the edges of a sandy track through mixed woodland between 2000 and 2004 by TWD. This earthstar is uncommon in Britain and largely restricted to the southern counties although there are early records from Yorkshire and a recent one from Nottinghamshire.

Geastrum berkeleyi Berkeley's Earthstar

This genuinely rare earthstar appears to have occurred in Norfolk but once, at Blakeney Brecks (~TG 0243) in 1925 or 1926, a record attributed to F Yeo. This record is given by Ellis (1981) without further details but is not referred to by Cooke (1937). Its designation as possibly extinct in Britain (Pegler *et al.* 1995) was premature as there were subsequent records from Worcestershire in 1996; Herefordshire in 1999 and Hampshire in 2001.

Geastrum campestre Field Earthstar

This species was added to the Norfolk list as recently as 2006 when Paul Sterry found 'an old eroded specimen with only slight hygroscopic activity' at Holkham Meals (TF 8845); its identity was confirmed by Brian Spooner at Kew. Pegler *et al.* (1995) considers it to be introduced to Britain, although they state that it occurs throughout Europe. As with so many rare earthstars there has been a flurry of recent records: Surrey in 2001; Wiltshire in 2005 and Hampshire in 2007.

Geastrum corollinum Weathered Earthstar

The rays of this far-from-common species are often recurved and lose their mycelial layer with age. The first British record was from Norfolk in 1782, although the locality is not known. Since then it has occurred spasmodically with the most recent, and curious, record in 2006 from a greenhouse near Edgefield, identified by TWD. (Table 4). Its more usual habitat is hedge-banks or deciduous woods on well-drained base-rich soils. British records are scattered across the eastern half of England (with just a handful from North Wales). Pegler *et al.* (1995) point out that some of the relatively few records from the twentieth century require confirmation; the species is similar to *G. floriforme* but the latter is even rarer.

Geastrum coronatum Crowned Earthstar

This species is much commoner than the above and is more widespread in Britain but with, again, the greatest concentration of records from East Anglia, where in recent

Table 5. Records of *Geastrum coronatum*.

Year	Place	Grid	Name	Year	Place	Grid	Name
1864	Attlebridge	~TG 1316	KT	1980	Intwood	TG 1904	EAE
1867	Skeyton	~TG 2425	KT	1998	Harford, Norwich	TG 2105	JJR
1880	Hillington	~TF 7125	CBP	1998	Norton Subcourse	TM 4098	TWD
1938	Drayton	~TG 1813	RMSB	1999+	Holt Country Park	TG 0838	TWD
1939	East Wretham	~TL 9190	JML	1999	Brundall Gardens	TG 3108	TWD
1940	Blofield	~TG 3309	THP	2000	Earsham	TM 3290	TWD
1945	Eaton	~TG 2006	GJC	2000+	Marston Lane	TG 2205	TWD
1945+	Upper Hellesdon	~TG 2111	EAE	2000	Gayton	TF 7419	TWD
1946+	Surlingham	~TG 3006	EAE	2000+	Cockley Cley	TF 7804	JJR
1948+	Claxton	~TG 3303	RHS	2000	Keswick Old Hall	TG 2004	TWD
1951	Halvergate	~TG 4106	RK	2000	Saxthorpe Woods	TG 1132	TWD
1953	Ingham	~TG 3825	ARD	2001	Ipswich Rd., N'ch	TG 2207	TWD
1971	West Bradenham	~TF 9108	Tubby	2003	Wortwell	TM 2785	TWD
1978	New Costessey	~TG 1710	CAB	2003	Holkham Meols	TF 8845	TWD
1979+	Rockland St Mary	TG 3204	MN	2007	Holkham Gap	TF 8944	RGB

years it has been found relatively frequently (Table 5). It is most likely to occur on hedge-banks, often under hawthorn or oak and occasionally under beech.

Geastrum elegans Elegant Earthstar

The first British record for this earthstar was from Norfolk by JT Palmer at Great Massingham (~TF 7922) in 1882. Strangely it was not reported by CB Plowright whose interest by that time had moved on to the rust fungi. It appears to be genuinely rare with only seven further British records through the twentieth century, not all of them confirmed, from East Lothian to the Isles of Scilly and from Anglesey to East Suffolk. After a gap of 120 years an old specimen was found by M Rotheroe and ARL. in the spring of 2002 under pines at Holkham (TF 8845) and was identified by BM Spooner. During autumn of the next year SE Evans reported finding a fresh specimen in the same area.

Geastrum fimbriatum Sessile Earthstar

Tracing early records for this species is hampered by nomenclatural uncertainties as the name *G. rufescens* has also been used for this species. It is apparent from spore descriptions that Ellis (1981) uses the name in this way and refers to what is now accepted as *G. rufescens*, as *G. vulgatum*. *G. fimbriatum* is comparatively widespread through England and southern Scotland and is one of the few earthstars to occur widely in Ireland. It appears to be getting commoner in Norfolk and is typically found on hedge-banks and along the edge of woods, both coniferous and deciduous (Table 6).

Geastrum floriforme Daisy Earthstar

Although it might be getting commoner, with around a dozen British records since it was first found in Lancashire in 1952, this is still a rare fungus which favours the east of England. It was added to the Norfolk list by EA Ellis who found it at Heacham (TF 6737) in 1981 and at nearby Old Hunstanton (TF 6840) in the following year. In Norfolk it is a coastal species, growing on bare sand between patches of well-grazed turf in exposed sites. Very recently (2009) a third site was located when four specimens were found by P Amies and G Hibberd at

Table 6. Records of *Geastrum fimbriatum*.

Year	Place	Grid	Name	Year	Place	Grid	Name
1872	Castle Rising	~TF 6624	CBP	1987	Santon Downham	TL 8187	REE
1902	Cromer	~TG 2141	CR	1990	Grimes Graves	TL 8189	REE
1948	Norwich	~TG 20	GJC	1990	Lynford Hall	TL 8194	REE
1952	Mousehold Heath	TG 2410	EAE	1993	Croxton Heath	TL 8690	REE
1954	Holt	~TG 0838	GCJ	1998+	Emily's Wood	TL 7989	REE
1956	Hingham	TG 0301	EAE	1999+	Holt Country Park	TG 0838	TWD
1958	Holkham Dunes	~TF 8944	EAE	2000	Cranworth	TF 9804	REE
1977	Bacton Woods	~TG 3130	EAE	2001	Norwich	TG 2216	TWD
1980	East Harling	~TL 9986	EAE	2001	Sheringham Park	TG 1441	TWD
1983	Bacton Woods	TG 3131	REE	2002	Bridgham Picnic Site	TL 9683	JJR
1985	Bridgham Picnic Site	TL 9683	REE	2002	Weeting Heath	TL 7688	TWD
1985	Felthorpe Woods	TG 1416	REE	2003	E. Walton Common	TF 7316	ALB
1986	Emily's Wood	TL 7989	REE	2003	Croxton Heath	TL 8690	ALB

Holme (TF 7144), barely 3 km from the 1982 record.

Geastrum fornicatum Arched Earthstar

This earthstar gets its intriguing specific name from the Latin *fornix*, meaning arch, as it is one of the two British species in which the mycelial layer separates from the exoperidium and reflexes downwards while remaining attached to the rays at their tips. It is not common in Britain and like so many earthstars it has a predominantly south-eastern distribution. Half of the Norfolk records have been made in the last decade (Table 7).

Geastrum lageniforme Flask Earthstar

Although still nationally rare, this earthstar is being recorded increasingly frequently but has not been found in Norfolk for nearly 100 years. The first record for the county is that by the Rev. K Trimmer in, or near, Norwich in 1873. C Rae recorded it at Cromer in 1902 and GJ Cooke at Earlham, also in Norwich, in 1912. A difficulty here is that this species is very similar to specimens of *G. triplex* that have failed to develop the characteristic collar, a not unusual phenomenon. There are microscopic differences but spore size is not one of them (according to

Table 7. Records of *Geastrum fornicatum*

Year	Place	Grid	Name	Year	Place	Grid	Name
1815	North Elmham	~TF 9820	JP	2000+	Forncett St. Mary	TM 1694	TWD
1872	Billingford	~TG 0120	KT	2000+	Cockley Cley	TF 7804	JJR
1924	East Dereham	~TF 9912	MP	2001	Narborough	TF 7711	TWD
1937	Crown Point	~TG 2506	RJC	2002	Ringland	TG 1415	TWD
1954	Sprowston	~TG 2411	WEHF	2003	Cockley Cley	TG 8005	JJR
1974	Norwich	TG 2310	EAE	2006	Pott Row	TF 6921	JJR
1983	Narford Hall	TF 7613	REE	2007	Frettenham	TG 2418	TWD
1999	Itteringham	TG 1431	TWD	2007	Raveningham	TM 3896	TWD
2000+	Forncett St. Mary	TM 1694	TWD				

Pegler *et al.* 1995) despite a suggestion to the contrary in Ellis (1981). A further complication is that *G. saccatum*, the name under which Ellis describes this species, is recognised as a distinct species in the USA and Europe but not in Britain.

Geastrum minimum Tiny Earthstar

If any earthstar can be thought of as Norfolk's own, *G. minimum* is that species. It is not quite a Norfolk endemic in the British Isles as it has been found on the Cumbrian coast at Ravenglass (Legon & Henrici 2005), although this record does not appear on the FRDBI. A record for it from the Isle of Man is unsupported by voucher material. It was first found in Britain at Holkham, by EA Ellis in 1958, and confirmed by JT Palmer, the expert on gasteroid fungi. Its stature alone cannot be used to establish its identity as half a dozen species can be less than 20 mm in total diameter (Figure 4). The spore-sac is normally dusted whitish and is typically stalked, although sessile specimens have been found.

During the 1990s specimens were collected at Holkham by a number of people including A Harrap in 1993 and by MJ Telfer and L Gresser in 1995 (Telfer *et al.* 2000). Monitoring work by the Norfolk Fungus Study Group (particularly by TWD, JJR and T Money) since 2000 has established that there are a number of small populations within a few kilometres of each other. In a very detailed survey, supported by Plantlife International in 2009. AM Ainsworth found over 300 fruit bodies in 21 patches in this area Most are on sloping ground near the seaward edge of belt of Corsican Pine *Pinus nigra* where small patches of bare sand occur amongst rabbit-grazed turf with a high percentage of moss cover. The dunes are visited by large numbers of people, but although trampling and erosion have eliminated it from one vulnerable site, in general the earthstar appears to be thriving. Colonies also occur on the dunes to the west of the pines.

Geastrum pectinatum Beaked Earthstar

G. pectinatum bucks the trend by being rather commoner elsewhere in England than Norfolk, with just one locality in the county. This may be because it favours limestone under spruce, a habitat not found in Norfolk. When mature the spore sac of this species is normally a leaden grey. It was first found in 1954, also at Holkham Dunes, by TJ Wallace and in 1958 by EA Ellis and JT Palmer. In 1987 it was re-found by RE Evans in what might well have been the same site (TF 9045) but it has not been seen since despite this being a well-studied area.

Geastrum quadrifidum Rayed Earthstar

G. quadrifidum is distinctly less common than our other arched earthstar (*G. fornicatum*), both in Norfolk and in Britain. It was not found in Norfolk until 2000 when JJR collected it from a remarkable roadside bank at Cockley Cley (TF 7804); remarkable because it is a site not only for the rare Sandy Stiltball *Battarraea phalloides* but for six more species of *Geastrum*! Moreover the specimens found annually at this site are quite different from the normal form of this earthstar: they are at least two or three times larger, have up to six rays and the peristome does not sit on a flattened 'saucer'. L Jalink (pers. com.) notes that he has seen this form several times in the Netherlands but sees no reason to rank it as a subspecies or variety. Fresh young specimens can appear on casual observation to be *G. berkeleyi.*

A second Norfolk site was discovered in 2002 at Pratt's Hill, Surlingham (TG 3107) only about 2 km from the late Ted Ellis's home at Wheatfen, and a third, at Stoke Holy Cross in 2008, both by TWD. In the spring of 2009, D McNeil found a specimen under Yew *Taxus baccata* in Rushford churchyard (TL 9281).

Geastrum rufescens Rosy Earthstar

The rays of this earthstar can have a pinkish tint but this is rarely as marked as its names might suggest. It is one of the more widely reported species in England (rarely reach-

Table 8. Records of *Geastrum rufescens*

Year	Place	Grid	Name	Year	Place	Grid	Name
1794	Trowse	~TG 2406	JS	1958	Honingham	TG 1010	EAE
1861	Drayton	~TG 1813	KT	1973	Briston	~TG 0632	HW
<1872	Hellesdon	~TG 2010	KT	1974	Weeting Heath	~TF 7587	(BMS)
<1872	Earlham	~TG 1808	KT	1974	West Harling Heath	TL 9784	EAE
1874	North Wootton	~TF 6424	JP	1994+	Lynford Arboretum	TL 8294	JJR
1936+	Sheringham	~TG 1442	GJC	1998	Emily's Wood	TL 7989	TWD
1936	Cromer	TG 2241	EAE	1998	Holkham Dunes	TF 9045	JJR
1938	Sparham Pools	TG 0718	EAE	1999	Stoke Holy Cross	TG 2301	TWD
1938	Earlham Park	TG 1907	EAE	1999+	Mousehold Heath	TG 2410	TWD
1952	Mousehold Heath	TG 2410	EAE	2000	Bridgham Picnic Site	TL 9683	JJR
1956	Surlingham	TG 3107	EAE	2001	Gressenhall Old Carr	TF 9717	REE
1956	Hingham	~TG 0202	EAE	2007	Lynford Arboretum	TL 8294	TWD
1958	Holkham Gap	TF 9045	EAE				

ing Scotland) and one of the commonest in Norfolk (Table 8). It has no coastal pretensions and although typically found on leaf litter also occurs in grassy places.

Geastrum schmidelii Dwarf Earthstar

Although the FRDBI gives the first Norfolk record as that of J Palmer at Winterton in 1874, Ellis (1981) states that this species is clearly illustrated in *Flora Londiniensis* (ca 1819) by WJ Hooker with the comment that it was 'common at Yarmouth Denes'. This small sand-loving species is not often met with in Norfolk and has not enjoyed the flush of recent records which have characterised some of its relatives (Table 9).

Geastrum striatum Striate Earthstar

Were it not for the basal collar projecting downwards from below the spore-sac this species would be hard to distinguish from *G. pectinatum*, although there are small microscopic differences. It is occasional to locally common in Norfolk (Table 10), where it occurs in woods and especially along their boundaries. It is one of the commoner earthstars and although it has been found farther north than any earthstar in Britain (on the south side of the Moray Firth) it is very much more abundant in East Anglia and the Home Counties.

Geastrum triplex Collared Earthstar

It is interesting that this distinctive earthstar, which is now by far the commonest in Norfolk and in Britain, was not mentioned by Plowright in any of his publications. It

Table 9. Records of *Geastrum schmidelii*

Year	Place	Grid	Name	Year	Place	Grid	Name
1874	Winterton	~TG4920	JP	1979	Burnham Overy	~TF8442	CPP
1874	Caister	~TG5111	JP	1984	Holkham Dunes	TF9045	REE
1880	Yarmouth	~TG50	GM	1987	Holkham	TF8745	REE
1949	Scolt Head Island	~TF8146	DAB	1990	Breckland		
1977	Holkham	~TF9045	BI				

Table 10. Records of *Geastrum striatum*

Year	Place	Grid	Name	Year	Place	Grid	Name
1849	East Carleton	~TG 1702	KT	1954	Upper Hellesdon	~TG 2111	EAE
1867	North Wootton	~TF 6424	CBP	1971	Aldeby	TM 4493	EAE
1890	Shotesham	~TM 2499	KT	1973	Mundford	~TL 8093	RPBO
1905	Swanton Abbott	~TG 2625	EM	1978	Cranworth	TF 9804	REE
1935+	Eaton	~TG 2006	GJC	1983	Bridgham Picnic	TL 9683	REE
1937	Stoke Holy Cross	~TG 2302	GCHC	1998	Itteringham	TG 1431	REE
1943	Mangreen	~TG 2103	GJC	2001	Harford Hills	TG 2205	TWD
1946	Claxton	~TG 3303	RHS	2002+	Holkham Gap	TF 8745	JJR
1948	Rockland St. Mary	~TG 3104	EAE	2002	Ringland	TG 1413	TWD
1950	Barford	~TG 1107	RWT	2003	West Norfolk		
1953	Surlingham	TG 3107	EAE	2005	South Walsham	~TG 3613	TWD

would seem that he had not personally encountered this species although Ellis (1981) reports that it is clearly figured by Bryant (no reference given), showing that it was present in the Norwich area in the 18th century. We must wait until Cooke (1937) for more formal records: by himself at Horsford Heath (~TG 1818), 1910 to 1914, and then nothing until 1932 (T Petch at Holkham Gap (~TF 9045) followed by seven more records in the next three years. Cooke comments that it appears to be becoming increasingly common in Norfolk and that trend has continued; the Norfolk Fungus Record Database contains 124 records for *G. triplex* from 62 sites between 1938 and 2007 (map see Figure 8), although still not widely reported from the Broads or from West Norfolk. It is abundant most years in Thetford Forest in the thick mossy needle litter below the pines but, although it may favour humus-rich soil, it can also occur on sandy soils beneath trees. Note that the 'collar' is formed by a cracking of the thick inner layer of the exoperidium as the fungus matures so is not apparent on young specimens.

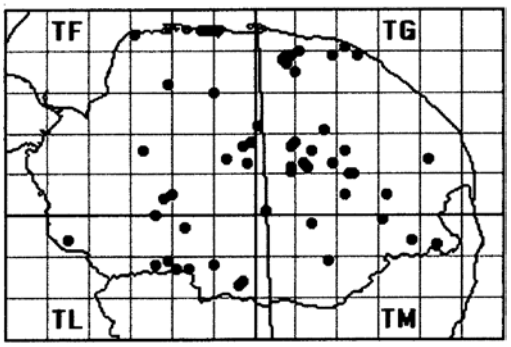


Figure 8 Records of *Geastrum triplex* since 1938

Myriostoma coliforme Pepper Pot

This distinctive earthstar, with its multiple stalks and openings, is the Holy Grail of Norfolk mycology, the more so since it was found in Suffolk in 2006 (on a sandy bank under oak)! It was first collected in Norfolk by TJ Woodward in 1794 from Earsham (~TM 3289) and Gillingham (~TM 4091), two localities near Beccles on the Norfolk side of the county boundary. He also collected it from two nearby localities just south of the Waveney. Plowright (1881) reports that at about this time it was found near Norwich by Sowerby but the record was never formalised. On 25th September 1880 CB Plowright was therefore very excited when four fruit bodies of this earthstar were brought to his house in King's Lynn, having been collected by Mr Philip Higben at nearby Hillington (~TF 7125) (Plowright 1881). They had been found 'growing upon a hedge-bank in a green lane (called the

Swaffham Road) amongst a large clump of nettles'. About three weeks later Plowright collected further specimens from the same location but in a withered state. These were the last collections of the species in the British Isles until the Suffolk record once again confounded the premature statement of its extinction in Britain by Pegler *et al.* (1995). *Myriostoma coliforme* occurs in Europe and in the 1990s was recorded from Jersey where it occurs on a sandy bank along a track leading to the sea. On a visit to the site, TWD found *G. fornicatum* and *G. pectinatum* on the same bank.

Suffolk earthstars

The original paper by Ellis (1981) was entitled *Earth-stars (Geastraceae) in Norfolk and Suffolk*, and the latter county is almost as rich in earthstars (13 have occurred there according to FRDBI). We prefer to leave a detailed account to our colleagues in Suffolk; a Suffolk Fungus Group now exists and a County Recorder has been appointed. Nevertheless, mention should be made of the earthstars in Brandon Country Park just over the border, where JJR has recorded no fewer than eight species (*G. coronatum*, *coronillum*, *fimbriatum*, *fornicatum*, *quadrifidum*, *rufescens*, *striatum* and *triplex*) and a ninth, *G. pectinatum*, has been reported.

Earthstar 'hotspots'

Whilst it is true that mycologists visiting the site of a rare fungus with their eyes open are more likely to spot new species, it is inescapable that a 'family' preference for particular habitats is shown by many groups of fungi. The association in Brandon Country Park is a remarkable example, now matched by Holkham Meals, a 4 km length of pine-covered dunes, with *G. campestre*, *coronatum*, *elegans*, *minimum*, *pectinatum*, *rufescens*, *schmidelii*, *striatum* and *triplex*. (Note that the statement by Leech *et al.* (2008) that there were only eight species at Holkham was erroneous; records had been entered under a number of different place names for the site.) In many ways an even more remarkable example of this clustering is at Cockley Cley, where a narrow road-side verge, no more than 150 m long, with scattered Scot's Pine, produces *G. coronatum*, *fimbriatum*, *fornicatum*, *quadrifidum*, *rufescens*, *striatum* and *triplex*.

Acknowledgements

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AR Leech 3, Eccles Road, Holt , Norfolk NR25 6HJ leech@dialstart.net

TW Dove 2 Kirklees, Tuckswood, Norwich NR4 6LP

JJ Revett Wigston Villa, Welney, Wisbech, Cambs PE14 9QA

Barometer Earthstar *Astraeus hygrometricus*

Field Earthstar *Geastrum campestre* (dried)

Weathered Earthstar *Geastrum corollinum*

Crowned Earthstar *Geastrum coronatum*

Sessile Earthstar *Geastrum fimbriatum*

Daisy Earthstar *Geastrum floriforme*

Arched Earthstar *Geastrum fornicatum*

Tiny Earthstar *Geastrum minimum*

Beaked Earthstar *Geastrum pectinatum*

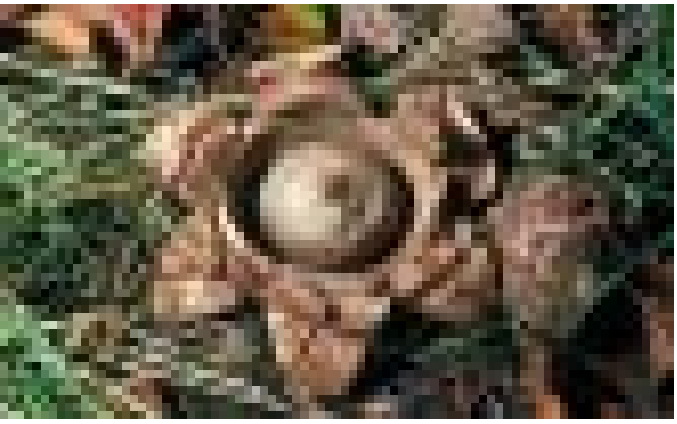
Rayed Earthstar *Geastrum quadrifidum*

Rayed Earthstar *Geastrum quadrifidum* (fleshy form)

Rosy Earthstar *Geastrum rufescens*

Striate Earthstar *Geastrum striatum*

Collared Earthstar *Geastrum triplex* (young)



Collared Earthstar *Geastrum triplex* (mature)

Pepper Pot *Myriostoma coliforme*

All photos by Jonathan Revett except *G. floriforme* (Gary Hibberd), *G. campestre* (dried) (Tony Leech) and *G. triplex* (mature) (Tony Leech).

All photos are of Norfolk or Suffolk specimens except *Myriostoma coliforme* (foreign).