

The Lepidoptera Collection of William Raymond Wooff (1929–2006) in the Manchester Museum

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ABSTRACT

The lepidopterans in Raymond Wooff's collection in the Manchester Museum are distinctively curated and represent an assemblage of insects in the classic Aurelian tradition but created in the twentieth century. This collection was established on index cards, with only butterfly/moth wings being mounted and laminated onto cards. Despite being such an unusual collecting and preservation technique, it illustrates how a dedicated field biologist, with limited resources, can amass a significant, data-rich Lepidoptera collection that provides reliable information on distribution, habitat preferences and phenology of the collected species. The present paper explores the history and content of this unusual Lepidoptera collection and its collector.

Keywords: Lepidoptera, curation, Aurelian tradition, Manchester Museum, England

INTRODUCTION

The Manchester Museum is the UK's largest university museum retaining approximately 4.5 million objects and specimens, ranging from nature to culture (Alberti 2009; Logunov & Merriman 2012). It is one of 32 non-national museums in England with designated collections of pre-eminent importance, announced by the Secretary of State on 24th June, 1997 (Report 1997). The Museum's Entomology Department houses some 2.5 million specimens and is likely to account for the third largest insect depository in the UK (Logunov 2010; 2012). The particular strengths of its entomological collections are the worldwide collections of Coleoptera, Dermaptera and Lepidoptera.

Some of the Manchester Museum's entomology collections and their biographies (*sensu* Hill 2014) have already been described: *e.g.*, the collection of British beetles (Johnson 1996; 2004), the worldwide collections of earwigs (Miles 2015) and tortoise-beetles (Higham 2012), *etc.* Of the vast lepidopteran collections of the Manchester Museum consisting of more than 150,000 specimens, only three have been studied and described to date: *viz.*, the general collection of British Lepidoptera (Logunov 2012), Joseph Sidebotham's Lepidoptera (Cook & Logunov 2016) and David Longsdon's collection of swallowtail butterflies (Dockery & Logunov 2015).

The aim of the present paper is to describe another museum Lepidoptera collection amassed by Ray Wooff (Fig. 1), a notable British medical entomologist who was particularly renowned for his studies on Tsetse flies (*Glossina* spp.) and their control in Africa. This lepidopteran collection is unusual among other museum insect collections in its preservation method, in which butterfly/moth wings were detached from insect bodies and laminated onto index cards (Figs 5, 6, 7, 9, 10 and 11).

In the text and figure captions, the following abbreviations are used: MMEA – Manchester Museum's Entomology Archive; M.E.S. – the Manchester Entomological Society.



Photo: © Anne McDowall

Fig. 1. — William Raymond Wooff during a fishing session on a river in North Yorkshire (UK), 2002.

BIOGRAPHY OF WILLIAM RAYMOND WOUFF

The details of the personal life of Wooff given below come from an obituary published by D.S. Hodgson (2010), the godson of W.R. Wooff, complemented with further data originating from various sources. William Raymond Wooff was born in Barnard Castle, County Durham, on 13 May 1929. He spent a good deal of his time as a young boy exploring local farmland, collecting birds' eggs, fishing and picking up rocks and fossils from local quarries. At the age of eleven years he went to Barnard Castle School, an independent school in the town where he lived.

At the school, his interests in natural history were encouraged by the teaching of Bentley Beetham, a very charismatic individual who had been on Mallory's expedition to Mount Everest in 1924. Wooff left Barnard Castle School in 1947 and entered National Service with the 6th Battalion Durham Light Infantry (Fig. 2), spending much of the time overseas in North Africa, Palestine and later East Africa. Apparently, during the military service he developed an interest in collecting guns and by the 2000s had assembled a collection of a dozen or so guns (David Hodgson, pers. comm.). After his National Service was completed, he went to King's College, University of Durham where he read Zoology and specialized in insect ecology. In July 1953, he left Durham with a BSc Degree in Zoology (Anon 2014) and his future wife, Shirley, and then he embarked on a PhD project researching insect ecology on the Farne Islands.

With his recently acquired PhD, he sought posts overseas and was employed in the Department of Tsetse Control in Uganda, researching methods of eradication of the Tsetse fly (*Glossina morsitans*) and its role in the control of sleeping sickness, and also recording and studying other biting flies (e.g., Wooff 1973a: b), including



Photo: © Durham County Record Office (/DLI 2/6/12/130)

Fig. 2. — William Raymond Wooff during his service with the 6th Bn. Durham Light Infantry, 1947–48.

Horse-flies (Tabanidae) (Fig. 3). Wooff assembled a large collection of Horse-flies that is now deposited in the World Museum of Liverpool. In 1963, he became the Chief Tsetse Officer in the Ministry of Animal Industry, Game and Fisheries in Uganda and was busy attending international meetings, such as the 10th, 11th and 12th ISCTR (International Scientific Council for Trypanosomiasis Research). He also published several papers regarding the state of Tsetse control in Uganda, for example, Wooff (1965; 1969). In 1970, his contribution to the development of animal production in Uganda was recognized by the award of the OBE (Order of the British Empire). Due to pressure of work, he was unable to attend an investiture in London, instead his insignia was presented to him by the British High Commissioner in Kampala, the capital of Uganda. His entomological work was also recognized by contemporary fellow-entomologists, with a new species of the stable flies – *Haematobosca wooffi* (Zumpt, 1969) (Muscidae: Stomoxyinae) – being described in his honour (Zumpt 1969).

Ray Wooff, his wife and two children, Anne and Michael, had to leave Uganda in 1972 after General Amin had made conditions for holders of British passports intolerable. They moved back to England and lived in Wilmslow, Cheshire. In the same year, he secured a post as a Senior Research Fellow at the University of Salford, in 1975 became a Senior Lecturer in Biology, and then (in 1984) a Senior Lecturer in Biological Sciences.

T.C. Form 2(e)

Survey/Observation Unit No. Month..... 19.....

Tabanidae CHECK LIST **BUDONGO FOREST**

Locality..... **BUDONGO FOREST**

Sub-county..... County.....

District..... **BUNYORO** Scheme.....

Period of Observations.....

Survey Method employed.....

Species and Numbers recorded:— **50**

	M	F		M	F
Ancala			fusca		X
africana		X	griseicoxa		
brucei			guineensis		X
fasciata <i>mixta</i>	X	X	hieroglyphica		
fasciata nilotica		X	hirsuticornis		
Atylotus			hirta		
agrestis		X	inornata		
fuscipes			lamborni		
Chrysops			lewisi		
brucei			marakuetana		
centurionis			neavei		
distinctipennis		X	nefanda		X
funebri		X	nefandoides		
griseicollis	X		nigripennis		
laniger			noxialis		
longicornis		X	partifascia		
Eanacala			patelliorne	X	X
maculatissima			pertinens		
maculatissima irrorata	X	X	similis	X	X

Photo: © Archive of the World Museum of Liverpool

Fig. 3. — Top half of a recording form used by R. Wooff and his co-workers in the studies of Horse-flies (Tabanidae) in Uganda.

When he returned to Wilmslow, England, and to his post at the University of Salford, Ray Wooff became an active member of the M.E.S. (about the society see Cook & Logunov 2017). He joined the Society in 1972 and later became a Council Member and subsequently their Secretary. In 1987, Wooff retired from the Council, though at their annual general meeting on 16 January 1988 he was made a Life Member. A note in the M.E.S. Secretary's report (MMEA, M.E.S. archive, box 3, item 123) stated that '*he was very busy with his preparations for his African trip*', so his ties with Africa remained strong. He left the University of Salford around 1991–1992 (Ian Johnston, pers. comm.), when he and his wife returned to Africa (Somalia and later Botswana), again working to develop ecologically friendly techniques to control Tsetse flies (*e.g.*, Wooff & Pillemon-Motsu 1993).

They finally returned to England, and specifically to Yorkshire, in 1994 and he resumed his earlier interests of entomology, geology, ornithology, etc. until his death in 2006. In November 2006, his collection of butterflies and moths was donated to Manchester Museum by his widow, Mrs Shirley M. Wooff.

THE WOUFF LEPIDOPTERAN COLLECTION

Wooff's collection of 2459 butterflies and moths was curated in a manner he apparently devised himself. His method of preservation, after hand-netting the majority of the specimens in the field, was to remove their wings and then place the dorsal surfaces of the forewing and hindwing of the right hand side of the body of

the specimen uppermost on an index card and place the ventral surfaces of the forewing and hindwing of the left hand side of the body, uppermost too, beside them. However, for reasons not currently apparent, he only used one pair of wings for the majority of the moths in his collection. Some of these were from the right side of the body and some from the left, though the right side of the body was predominant. This system of collecting and preserving butterflies and moths was very economic in terms of space, as all his specimens could be confined to six index card holders (Fig. 4), each being 37×17×7cm. Comparable numbers of lepidopteran specimens in most museum collections would probably require a considerable number of drawers in expensive wooden or steel cabinets.

All four (or two) wings were then laminated to: 1) preserve them in place on the index card; 2) prevent any subsequent damage to the wings; 3) allow all four (or two) wings to be clearly visible (Figs 5, 6, 7, 9, 10 and 11); and 4) enable him to leave Uganda with a collection of over 800 sets of Afrotropical butterfly wings that could be easily packed into a chest or suitcase. His method also now allows the cards to be scanned and digitized if/when necessary. Wooff's system also had the further advantage that the insects would not succumb to the ravages of the museum beetle or other pests, though the cards themselves will deteriorate in time. Nor would the Wooff collection of butterfly and moth specimens require the small drums of naphthalene that have historically been found in a typical museum drawer in many British museums to discourage pests. The drawback, of course, is that no body parts are preserved and thus identification based on somatic morphology or genitalia, which is required in many cases (e.g., Coutsis & van Oorschot 2011), is impossible.

He had probably designed the format of the index cards himself and then had the cards printed commercially to his own design (see Figs 5, 6, 7, 9, 10 and 11). This allowed detailed information, such as locality details (incl. coordinates), vegetation types, dates and times of collecting, weather, the collecting method used and the sex (if known) to be written on each card. Therefore each card in Wooff's collection contains an amount of important information about the collected and laminated specimen that well exceeds that of the usual data labels attached to pinned insects. This makes the collection of great scientific importance.

One limitation of the Wooff method of curation was, of course, that he was limited by the size of a standard index card as to which specimens he could accept in his collection. The larger species of butterflies, such as some of the birdwings, and species of moths, such as owl moths, would not fit on an index card. However, there are a few large butterflies in Wooff's collection, for instance, Common Birdwing (*Troides helena*) (Figs 5, 6). In the latter and similar cases, the second pair of wings was mounted on the back side of the index card.

The bulk of Wooff's insect collections and related materials were donated to the World Museum of Liverpool by his widow in 2007 on the ground that it was always his '*intention that the Tabanid collection should go to Liverpool, especially as they have the complementary material from the School of Tropical Medicine*' (archive of the World Museum of Liverpool). These consisted of 44 store boxes of Ugandan Tabanidae (Horse-flies) and a collection of recording forms used by Wooff and his co-workers (Fig. 3) when carrying out field research on the flies in five areas of Uganda, plus photographs of typical vegetation types in these areas. The flies caught in these samples (using methods that included bait cattle, Malaise traps, flies that rested on their Land Rover, etc.) were then identified to species and gender. The Liverpool collection also has a box of insects that Wooff collected on the Farne



Photo: © Manchester Museum

Fig. 4. — Six index card holders in which the Wooff Lepidoptera collection is kept.



Photos: © Manchester Museum

Figs 5–6. — Index card with the wings of Common Birdwing (*Troides helena*): 5, upper side of the card; 6, other side of the card. © Manchester Museum.

Islands when conducting his PhD research in the late 1950s, some offprints of papers relating to Tabanidae and some pieces of communication between the Museum and Mrs. Wooff.

A smaller part of the insects collected from the Farne Islands is in the Manchester Museum. In total, there are 78 true bugs (Heteroptera) and all were caught on the Inner Farne Islands. Most of them have a generic date on their label, *viz.* 1955–1956, but eleven do have specific dates ranging from 18/7/1955 to 22/7/1956. The insects include nine species in five families of Heteroptera (Myridae and Anthocoridae) and Auchenorrhyncha (Don Stenhouse, pers. comm.).

As evidenced from a document kept in the Wooff's archive at the World Museum of Liverpool, there were also pinned butterfly specimens in his collection. These seemed to have been sold to Watkins & Doncaster, together with empty Hill-cabinets, in late 2007 to early 2008; their number and whereabouts are unknown to us.

The carded lepidopteran material donated to Manchester Museum by the Wooff family, using the Ray Wooff designed index card system, can be divided into three sections: Afrotropical butterflies, New World butterflies and European butterflies and moths.

A. AFROTROPICAL LEPIDOPTERA

This collection consists of 837 specimens of 128 species in ten genera (Table 1; Fig. 7), overall accounting for only a tiny proportion (< 4%) of over 3600 butterfly species recorded from Africa (*cf.* Larsen 1995). Table 1 shows that males predominate in this collection, with the ♂/♀ ratio being 1.58/1.00.

TABLE 1. — SPECIMEN NUMBERS, GENDER, COLLECTING METHODS AND NAMES OF COLLECTORS IN VARIOUS SECTIONS OF WOUFF'S LEPIDOPTERA COLLECTION

	Collection sections		
	Afrotropical	New World	European
Category			
Specimens	837	68	1554
Genera	10	23 (+2 undet.)	208 (+3 undet.)
Species	128	26 (+5 undet.)	332 (+21 undet.)
Gender			
Male	464	33	944
Female	293	19	552
Unspecified	80	16	58
Collecting methods			
Caught	808	56	497
Reared	6	0	508
Unspecified	23	12	549
Name of collector			
Wooff	816	62	726
Fielding		2	119
Robson		1	253
Thwaytes			56
Burrows			97
Others	3	1	232
Unspecified	18	2	71

TABLE 2. — COUNTRIES/COUNTIES OF ORIGIN IN THE VARIOUS SECTIONS OF WOOFF'S LEPIDOPTERA COLLECTION

Afrotropical	Collection sections – countries/counties (UK)				
	New World		European		
Botswana	448	Canada	2	Austria	22
Gambia	6	Costa Rica	54	Eire	25
Kenya	26	Formosa	1	France	30
Sierra Leone	1	Trinidad	1	Germany	16
Somalia	111	Panama	2	Others (countries)	14
Uganda	159	United States	2		
Zambia	46	Others (countries)	0	Cheshire	125
Zimbabwe	19	Unspecified	6	Cumbria	78
Others (countries)	0			Dorset	35
Unspecified	21			Durham	391
				Hampshire	73
				Kent	72
				Lincolnshire	41
				North Yorkshire	44
				Staffordshire	36
				Sussex	31
				Others (countries)	341
				Unspecified	180
Total	837		68		1554

Of the ten genera assembled by Wooff, species of Caper Whites (*Belenois* spp.; 133 ex) and Arabs (*Colotis* spp.; 370 ex) predominated, accounting together for 83.3% of all his Afrotropical specimens. Both genera are predominantly Afrotropical, but also occur in the Oriental and Palaearctic Regions. In Africa, there are 27 species of *Belenois* Hübner, 1819 and 40 species of *Colotis* Hübner, 1819 (d'Abbrera 1980), of which Wooff assembled seven *Belenois* species (26% of their African diversity) and 29 *Colotis* species (73%). So, the Wooff Afrotropical collection is fairly representative of these two genera, as far as their Afrotropical diversity is concerned. The reason why he collected rather long series of species in both genera seemed to have been his intention to illustrate a 'range of form, sexual and seasonal dimorphism and geographic variation' in these species, as stated on one of the index cards from the collection (Fig. 8).

Of course, since Wooff identified and assembled his collection, some changes have been made to the butterfly nomenclature. Thus, the species *brigitta*, principally found in Botswana, was originally assigned to the genus *Colotis* but is now in *Eurema*, which is a widespread genus with over 70 species occurring across several African countries, and also in Asia, Australia, Oceania and the New World (Smart 1981). Wooff's collection includes *Eurema* species from Uganda, Kenya and Zambia.

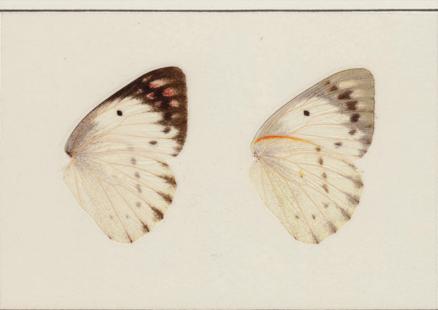
Table 2 shows the countries where the specimens were collected by Wooff. Uganda, Botswana and Somalia are dominant and are where Wooff was based for a number of years. Zambia, Zimbabwe, Kenya and Gambia, supplied smaller numbers of specimens and these may have been provided by researchers or caught by Wooff himself when he visited these locations for conferences, or perhaps when he was on a personal holiday or a business trip. Thus all the Zambian butterflies (46 ex) were collected in just one month in July 1978, all the Zimbabwe butterflies (19 ex) in May 1993 and all the Kenyan butterflies (26 ex) in January 1982.

TABLE 3. — YEARS AND MONTHS OF COLLECTING IN THE VARIOUS SECTIONS OF WOOFF'S LEPIDOPTERA COLLECTION

	Collection sections		
	Afrotropical	New World	European
Years			
1880–1889	0	1	1
1890–1899	0	0	33
1900–1909	0	0	95
1910–1919	0	0	162
1920–1929	0	0	98
1930–1939	0	0	67
1940–1949	0	0	224
1950–1959	2	0	484
1960–1969	105	0	51
1970–1979	89	2	122
1980–1989	149	0	21
1990–1999	467	54	2
2000–2009	0	0	1
Unspecified	25	11	193
Months			
January	160	54	2
February	22	0	17
March	108	0	41
April	28	0	45
May	165	0	123
June	94	2	284
July	109	0	376
August	75	0	231
September	42	0	126
October	3	0	53
November	0	0	23
December	7	0	4
Unspecified	24	12	229
Total	837	68	1554

Table 3 illustrates when Wooff collected his specimens, the data being represented in ten year intervals. This interval was chosen arbitrarily to cover dates for all three sections. The early peak period of 1960–1969 corresponds with the initial years when he arrived in Africa to work for the Ugandan government. No doubt he would have spent time travelling around Uganda collecting data and building up his experience relating to the conditions in the country that allowed him to identify ‘hotspots’ for Tsetse flies where the eradication schemes could be concentrated. Between 1960 and 1964 he collected 104 of the 159 specimens (65.41%) in Uganda, almost two thirds of the total.

The other peak periods of butterfly collection were 1980–1989 and 1990–1999, which correspond with his second spell in Africa when he went with his wife to Somalia and Botswana, where he became involved again with programmes to reduce the impact of Tsetse flies (Wooff & Phillemon-Motsu 1993). As he travelled around he must have been able to allocate time to follow up on his interest in Lepidoptera and so build up his collection of butterfly wings from species native to Somalia and Botswana and some neighbouring countries. In this period he collected a substantial number of specimens, 576 out of 837 (*i.e.*, 68.8% of the total). He

family PIERIDAE: PIERINAE	genus	COLOTIS	sp.	REGINA Grimen	sex	♀	ref. no.	2/09/170		
	ssp. name		form gen.	wet season	var. ab.		F3382-748			
7			loc.	NXOTEGA		grid	S 20.03.47	alt.		
			ref.	E 23.20.24	country					
			dist.	NGAMILAND						
			prov.							
			country	BOTSWANA						
			date	20 FEB 1993	time	1000-1100				
			weather	wet season						
			coll. method	netted						
			coll.	W. R. Wooff						
			notes	part of a stream of Barotsi						
8	<p>floor of a small valley, open Acacia erioloba/Combretum herbaceous bushland, with grass-dominated herb layer. crossing the valley, flying in a north-easterly direction</p>									
<p><i>Colotis</i> Hübner 1819</p> <p>Verzeichniss bekannter Schmetterlinge S.79</p> <p>examples illustrating range of form, sexual & seasonal dimorphism and geographical variation</p> <p>from the collection of Dr William R Wooff</p>										

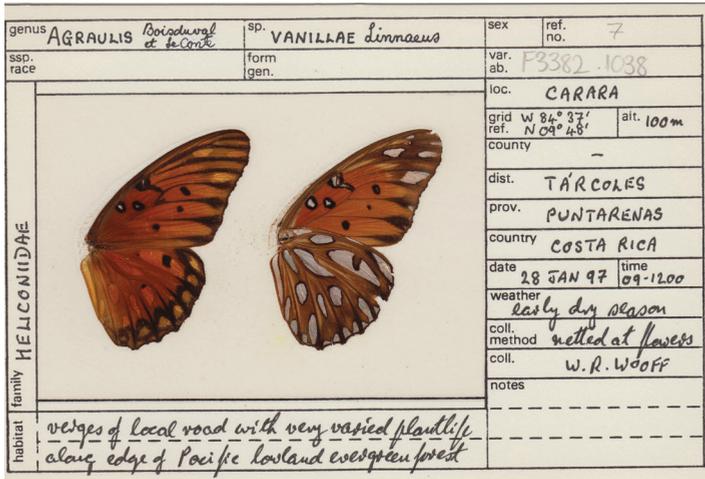
Photos: © Manchester Museum

Figs 7–8. — Index cards from the Afrotropical section of Wooff collection: 7, laminated wings of Queen Purple Tip (*Colotis regina*); 8, index card preceding the section containing the samples of *Colotis* species.

appears to have been a focused individual as he caught, with a butterfly net, 96.5% of his Afrotropical collection himself, with only a relatively few specimens being provided by other collectors (see Table 1). Once caught, his method of curation and time spent adding the details of each capture to its own record card would have been considerable. Table 3 reveals that the adult butterflies were principally netted in the first six months of the year, in response to the time of adult emergence of each species of butterfly in Uganda, Botswana and Somalia.

B. NEW WORLD LEPIDOPTERA

This section consists of a mixed composition of the butterflies collected from several zoogeographical regions (Table 2): Nearctic (Canada, USA), Neotropical (Costa Rica, Trinidad and Panama) and even Oriental (Formosa), with the majority



Photos: © Manchester Museum

Fig. 9. — Index card with the wings of Gulf fritillary (*Agraulis vanillae*) from Costa Rica.

(61 ex; 90%) originating from the Nearctics and Neotropics. As all these butterflies are amalgamated in Wooff's collection, we have considered them together as 'New World Lepidoptera'. In total, there are 68 specimens belonging to 26 species in 23 genera, plus undetermined taxa (see Table 1). Of these specimens, 33 were males and 19 females, with the ♂/♀ ratio being 1.74/1.00; 16 specimens were not identified as to their gender (Table 1). This ♂/♀ ratio is similar to that in the Afrotropical collection.

In contrast to his Afrotropical collection, with just 10 genera represented in the 837 specimens, Wooff's New World collection of 23 genera (68 specimens) reveals a much greater diversity. At least 1323 butterfly species have been recorded from Costa Rica (DeVries 1983), which is believed to represent approximately 5% of the world diversity of butterflies (Wiemers & Fiedler, 2008). Wooff caught 31 species (54 ex) when collecting butterflies in Costa Rica (Table 3; Fig. 9) in just one month, January 1997, which would be 2.3% of the total species number in the country. Of these 31 species, the most frequent nettings were of Banded Peacock or Fatima (*Anartia fatima*; 9 ex) and Barred Yellow, Fairy Yellow or Barred Sulphur (*Eurema daira*; 7 ex), which are nearly 30% of the total number of butterflies Wooff caught in Costa Rica. Neither of these two species is rare in the country (d'Abrera 1981; DeVries 1983) so, presumably, Wooff did not face any conservation issues when collecting them. Wooff's New World collection is clearly small but nevertheless gives a flavour of the great diversity of butterflies in Costa Rica.

The non-Costa Rican butterflies (Table 2) are ones seen in either North America, Red-spotted Purple Butterfly (*Basilarchia astyanax*) and Little Wood Satyr (*Megisto cymela*), or in SE Asia: Great Orange-tip (*Hebomoia glaucippe*) and Common Birdwing (*Troides helena*). The *M. cymela* examples are from the collection of E.H. Fielding and that of the *H. glaucippe* is from J.P. Robson, both well-known British lepidopterists and collectors (see below). We do not know how Wooff acquired the specimens from these two gentlemen, but he certainly purchased his *T. helena* specimen from Watkins & Doncaster as this is recorded on its index card (Figs 5 & 6).

This company was established in 1874 (Salmon 2000) as suppliers of natural history equipment, livestock and deadstock in The Strand in London. They later moved to Kent and are currently based in Leominster, Hereford and Worcester, and still supply all manner of equipment for the study of the natural sciences. The provenance of the *Basilarchia astyanax* specimen is currently unknown.

Tables 2 and 3 provide details of where the specimens were collected and the year and month when they were caught. The 54 Costa Rican specimens are dominant and were all caught in January 1997 and it may have been when Wooff was on holiday or attending a conference or similar event. Since he also caught the bulk of the specimens himself (Table 1), it would appear that his butterfly net was a much travelled and vital item of luggage.

C. EUROPEAN LEPIDOPTERA

This is by far the largest of Wooff's three sections consisting of 1554 butterfly and moth specimens (Figs 10–11). The number of genera and species (Table 1) are higher too than those of the two aforementioned sections and reflect the fact that Wooff was collecting lepidopterans over a much greater period of time than when he was abroad, even accounting for the greater diversity of species in tropical areas because of the higher number of biomes, including forests, deserts, grasslands, mountains, lake systems, etc. (Scholtz & Mansell 2009).

A notable difference between the European collection and other sections is that the European specimens include moths as well as butterflies. Of the 332 known species in Wooff's European collection (see Table 1), only 60 are species of butterflies (though two species are undetermined), whilst the larger number (272 species) are macro-moths.

Six lepidopteran species are particularly numerous: Green-veined White (*Pieris napi*; 75 ex), Small White (*P. rapae*; 11 ex), Large White (*P. brassicae*; 10 ex), Magpie (*Abraxas grossulariata*; 37 ex), Large Thorn (*Ennomos autumnaria*; 33 ex) and Gypsy Moth (*Lymantria dispar*; 26 ex). The Whites are common throughout the British Isles and none appears to show the recent decline evident for a number of other British species (Thomas & Lewington 2010). We do not know why so many *P. napi* were collected, but it may have been for research that Wooff, or one of his PhD researchers, was carrying out. The specimens were collected at sites across the United Kingdom and Eire and also at single sites in both Austria (Söll) and Germany (Treysa). For the latter two locations, most were taken in 1980 and may have coincided with visits to these areas for a holiday or conference. Of the moth species, six Magpies out of the total of 37 were each provided from sources in Surrey, Kent and South Yorkshire. It is a resident and common moth in Britain (Waring & Townsend 2009). The 33 Large Thorns were obtained by Wooff from two counties, Kent and Hampshire, but over several decades. All the specimens of Gypsy Moth were reared from sites in Germany, in 1950 and 1970. This is because its status in the British Isles is that of an immigrant, with reinforcements from the continent (Waring & Townsend 2009). It is interesting to note that the Gypsy Moths in the collection have a gender ratio of 1.00/1.00 and it is significant that they were all reared. In the wild it is only the males that fly, the females seem to restrict their egg-laying and flights to the vegetation (trees and bushes) where they spent their larval state (Skinner 1998).

Table 1 illustrates the gender of the lepidopterans in the European collection. Neglecting the specimens whose gender was not known, it is evident that the ♂/♀

TABLE 4. — SPECIMEN NUMBERS, GENDER, COLLECTING METHODS AND NAMES OF COLLECTORS IN WOUFF'S EUROPEAN LEPIDOPTERA COLLECTION

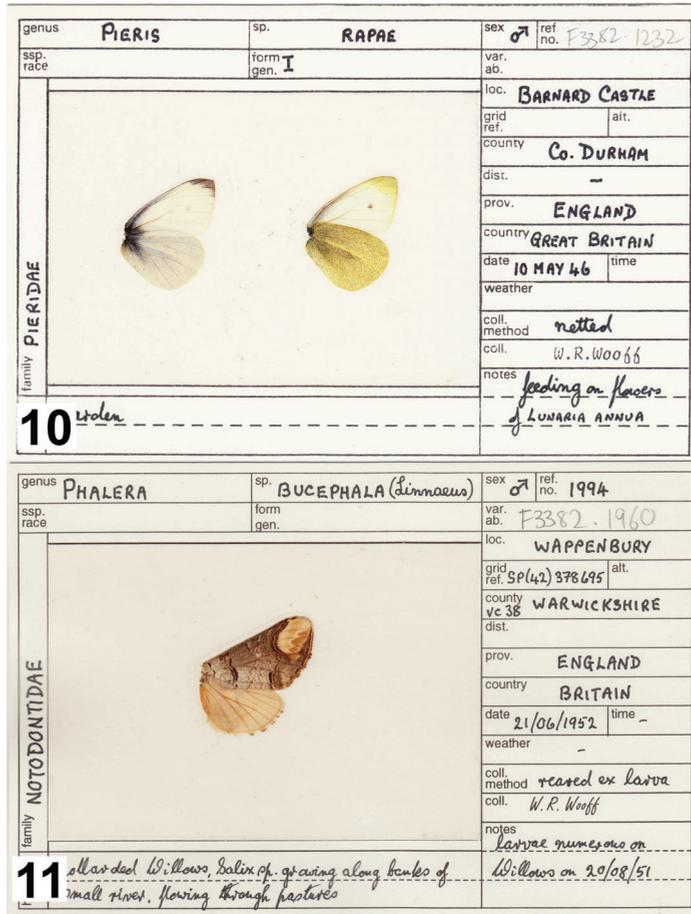
Category	Butterflies		Moths		Total
	No.	%*	No.	%**	
Specimens	287		1267		1554
Genera	39		169		208
Species	60		272		332
Gender					
Male	158	55	786	62	944
Female	85	30	467	37	552
Unspecified	44	15	14	1	58
Collecting methods					
Caught	77	27	420	33	497
Reared	44	15	464	37	508
Unspecified	166	58	383	30	549
Collector					
Wooff	132	46	594	47	726
Fielding	42	15	77	6	119
Robson	33	12	220	17	253
Thwaytes	0	0	56	4	56
Burrows	1	0	96	8	97
Others	27	9	205	16	232
Unspecified	52	18	19	2	71
	287		1267		1554

* % of the total number of butterflies (287)

** % of the total number of moths (1267)

ratio for all the Lepidoptera is 1.71/1.00, but when the ratios for the butterflies and moths were calculated separately the ratios were 1.86/1.00 and 1.69/1.00 respectively. So, similar ♂/♀ ratios were found. This male bias in collecting moths and butterflies was also evident in another of the major butterfly collections in Manchester Museum, viz. that of David Longsdon's Papilionidae (Dockery & Logunov 2015), in which usually five males and three females of each species are often presented, with the ♂/♀ ratio being 1.67/1.00. The preponderance in collections may simply be due to the preference, by humans, to respond to the greater variation in colour in their choice of specimens. So, more males may be selected by collectors when assembling their specimens as in many animal species, including Lepidoptera, males are often more colourful than females.

The index cards in the Wooff European collection also recorded the method of collection of the Lepidoptera (see Table 4). The individual details of the methods used varied. Some specimens were collected 'at flower', others were captured using a 'Tilley lamp', some were simply described as being 'netted' in the field, others in more unusual ways, such as 'resting on a tree' and a number were obtained as eggs or larvae then bred through to adults. These methods could conveniently be described as being either 'caught' or 'reared'. Many record cards lacked these details and so were recorded for this investigation as 'unspecified'. The numbers 'caught' and 'reared' are very similar but both are exceeded by the number of 'unspecified' examples. The 'unspecified' category is high and this is not surprising as Wooff had a very eclectic collection of specimens from many sources and he would not necessarily have been aware of how the original collector took his/her specimens. Many of the index cards record that the moths were taken at a Tilley lamp.



Photos: © Manchester Museum

Figs 10–11. — Index cards from the European section of Wooff collection: 10, laminated wings of Small White (*Pieris rapae*); 11, laminated wings of Buff-tip (*Phalera bucephala*).

Presumably, Wooff used a butterfly net to collect the moths as they arrived close to the light from the lamp. The Tilley lamp was invented by John Tilley in 1813. The lamp uses paraffin as the fuel and produces a steady, bright, white light. As it is easily portable it proved ideal for use in the field to catch moths (Heath 1976). In the latter half of the twentieth century battery or mains powered moth traps have been almost exclusively used by lepidopterists as these are much safer and more convenient.

Table 5 contains data indicating the month and the year when the European specimens were taken. For the months of the year, the pattern is as might be expected for butterflies and moths with the numbers peaking in the summer months (June, July and August) in the northern hemisphere. The years when the individual specimens were taken to be incorporated into the Wooff European collection were arbitrarily grouped into decades. The data indicate that most of the lepidopterans were taken in the middle of the twentieth century when Wooff was actively

TABLE 5. — YEARS AND MONTHS OF COLLECTING IN WOOFF'S EUROPEAN LEPIDOPTERA COLLECTION

	Butterflies	Moths
Years		
1880–1889	0	1
1890–1899	1	32
1900–1909	0	95
1910–1919	9	153
1920–1929	6	92
1930–1939	15	52
1940–1949	28	196
1950–1959	37	447
1960–1969	17	34
1970–1979	54	68
1980–1989	20	1
1990–1999	0	2
2000–2009	0	1
Unspecified	100	93
Months		
January	0	2
February	0	17
March	0	41
April	3	42
May	33	90
June	44	240
July	53	323
August	40	191
September	13	113
October	3	50
November	0	23
December	0	4
Unspecified	98	131
Total	287	1267

collecting himself and when he was able to boost his collection by obtaining more specimens from many other collectors and breeders of livestock, some of whom he probably knew personally.

The collectors who contributed a significant number of specimens to the Wooff European collection are shown in Table 4. It is apparent that almost half (46.56%) of the lepidopterans were assembled by Wooff himself. The other two principal collectors were J.P. Robson (16.33%) and E.H. Fielding (7.65%). J.P. Robson was a well-known collector and supplier of butterflies and moths in North East England. He was also a member of the Birtley Natural History Society and their lepidopteran correspondent. Birtley is a small village 16km NW of Hexham, Tyne and Wear. Robson would regularly provide copy for a local natural history magazine called '*The Vasculum*', which published articles, notes, records and other details relating to natural history. Fielding was an active member of the M.E.S. and its Secretary from 1952–1963 (Cook & Logunov 2017). Fielding (1961) wrote an article entitled '*The Fifties*' in the M.E.S. Annual Report, outlining the development of the Society in the previous decade. Later, he also prepared a special issue of the Society's Proceedings and Transactions devoted to H.L. Burrows, the ex-President (1930–1931) and one of

the stalwarts of the M.E.S., on his death (Fielding 1974). Wooff became the M.E.S Secretary in 1986 and so it is likely that Wooff would have known Fielding quite well.

The numbers of specimens that originated from the UK's counties are outlined in Table 6, together with a few specimens from some European countries. The range in the number of specimens from the different counties is 361, with Sussex providing 30 specimens and Durham showing the greatest number, 391, followed by Cheshire with 125. Durham was, of course, where Wooff went to school and lived for many years before his period of work on tsetse fly control in Africa. Wooff also spent several years living in Cheshire when working at the University of Salford and Cheshire shows the second greatest number of specimens from the listed counties. In fact, one in three (33.18%) of the total number of specimens originated from the two counties: Durham and Cheshire. Wooff would, no doubt, have been collecting moths during the summer months in his garden, first in Durham and later in Cheshire, hence their dominance. Of the other counties listed in Table 6, all except Staffordshire have coastlines and some of the collecting could have been undertaken when he and the family were on vacation breaks.

We have already drawn attention to a major difference between the European and the two other sections, *viz.* only the former has moths as well as butterflies. The dominance of moths in the collection can be seen in Table 4, there being over four times as many moth specimens as butterfly specimens, with similar ratios for genera and species too. The ♂/♀ ratios for the butterflies and moths are 1.85/1.00 and 1.68/1.00 respectively, which are similar to the gender ratios for the Afrotropical and New World collections. Further differences can be seen regarding the methods used to catch specimens, who collected them (Table 4), where they were caught and the year and the month when they were taken (Table 5).

TABLE 6. — COUNTRIES/COUNTIES OF ORIGIN IN WOOFF'S EUROPEAN LEPIDOPTERA COLLECTION

Countries/counties	Butterflies	Moths
Austria	22	0
Eire	23	2
France	22	8
Germany	6	10
Others (countries)	14	0
Cheshire	20	105
Cumbria	3	75
Dorset	13	22
Durham	12	379
Hampshire	1	72
Kent	4	68
Lincolnshire	16	25
North Yorkshire	6	38
Staffordshire	1	35
Sussex	2	28
Others (counties)	44	297
Unspecified	77	103
Total	287	1267

Of the numbers of butterflies and moths in the collection (Table 4), higher percentages of moths were 'caught' and 'reared' than for butterflies. This might be expected since moths are primarily collected by a light trap. As we know, Wooff regularly put out a moth trap in his garden in Wilmslow (Anne McDowall, pers. comm.), which thus would be the source of many of the British moths that are in his collection. Netting butterflies is less predictable. If mated female moths are trapped, and then confined to a small container, with or without suitable vegetation, they frequently lay eggs after a day or so and rearing them is then fairly straightforward.

Table 4 reveals that Wooff himself collected just under half of all the lepidopterans in the European collection, with little difference between the percentages of moths and butterflies. The unspecified percentage for butterflies was considerably higher than for moths, which reflects the fact that many of the butterflies in the collection came from European countries and were probably supplied by collectors or dealers who Wooff would not have known and who had not provided any locational details regarding the capture site.

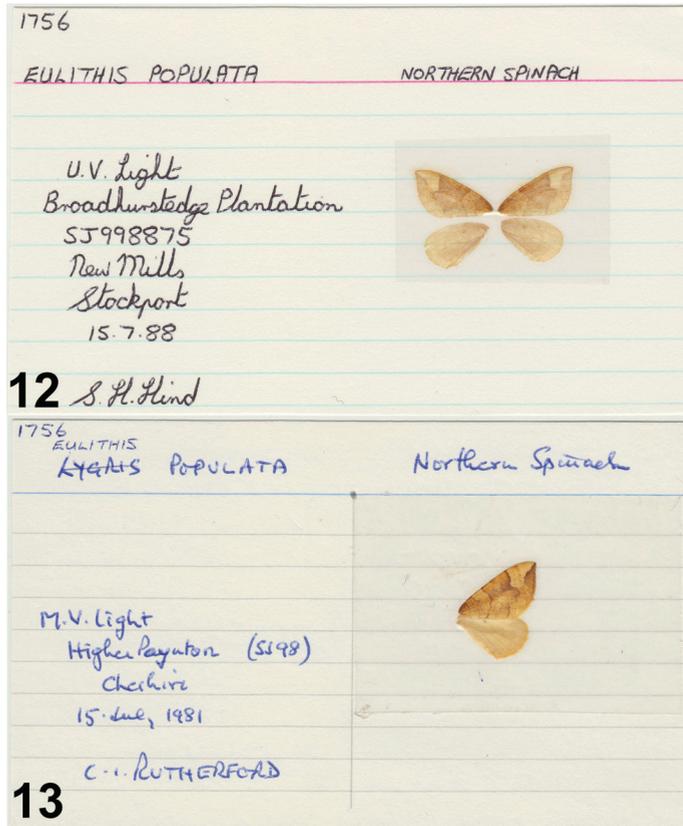
A striking feature of the difference in the sources of the European collection (Table 6) is that more than 30% of the butterflies (87 ex) came from a number of countries outside the United Kingdom whereas the percentage for moths is less than 2% (20 ex). The majority of these butterflies were caught by Wooff himself, probably taken when he was on holiday in Eire, Germany, Austria and France.

Table 5 shows a similar trend for the numbers of butterflies and moths collected in each month of a year. An important difference is that the period for collecting moths, as adults and larvae, extends over the year as a number of adult moths are on the wing in the period from October to February, such as Winter Moth (*Operophtera brumata*) and November Moth (*Epirrita dilutata*) (Waring & Townsend 2009), or as larvae, such as Scarce Silver-lines (*Bena bicolorana*) and many noctuid moths (*Mythimna* spp.) (Leverton 2001).

The majority of the dated moths in the European collection (about 40%) were captured in the two decades in the middle of the twentieth century (Table 6). Whilst good numbers of British butterflies were captured in these two decades the peak was reached in the 1970s. Of the 54 caught in this decade, 29 were *P. napi* and may have been collected for a specific research project. The peak numbers of moths caught (447 ex; 35.28%) occurred in the period 1950–1959. During this decade, Wooff was initially an undergraduate and then a postgraduate so had time to run Tilley lamps and moth traps to build up his collection of British moths. By the end of this decade he left for Uganda and his trapping in Britain ceased. It is also interesting to note that of the 93 moths classified as 'unspecified' or 'undated', 49 are in the Arctiidae family and the subfamily Arctiinae. These moths, including the tiger moths, are highly colourful, and some are poisonous, which might explain their attraction to a collector such as Wooff.

DISCUSSION

Raymond Wooff's collection of nearly two and a half thousand lepidopterans was accumulated over more than six decades, with approximately 65% being caught by Wooff himself. Others were probably obtained through purchases or by gift. We do not know when his interest in acquiring lepidopterans began but it is likely to have been when he was a schoolboy. Making collections of items of interest, such as butterflies, moths, shells, birds' eggs, fossils, etc., was still an acceptable activity for



Photos: © Manchester Museum

Figs 12–13. — Index cards with laminated wings of Northern Spinach (*Eulithis populata*) from the collection of Stephen Hind: 12, the specimen mounted by S. Hind; 13, the specimen mounted by Charles Ian Rutherford (further explanations are in the text).

schoolboys in the first half of the twentieth century. Even two of the 20th-century British prime ministers collected butterflies as young men: *viz.*, Neville Chamberlain and Winston Churchill (Marren 2015). Today in the UK, Lepidoptera collecting is strictly regulated by special governmental legislation and the policy of the UK's Butterfly Conservation (2010). Wooff lived in a small market town as a boy and so access to the countryside was relatively easy. He took to collecting insects very readily it seems and he also acquired specimens from other collectors and dealers to widen his collection and cover areas of Great Britain that he was unlikely to visit.

Preservation method

The chief characteristic of the Wooff collection is that only the wings of each insect were preserved, the rest of the body being discarded, the wings carefully positioned and then laminated. After preparation, detailed information was added to each card (Figs 7, 9, 10 and 11). We do not know when he devised his technique of specimen presentation but it proved to be an effective and space-saving method of developing a collection and was considerably cheaper than purchasing mahogany drawers and cabinets.



Photo: © Buckinghamshire County Museum

Fig. 14. — Slide preparations with Diptera specimens from the collection of Cecil Monk at the Buckinghamshire County Museum (top) and an example of the ring-binders with additional information about the slides.



Photo: © Manchester Museum

Fig. 15. — Examples of slide preparations with Lepidoptera wings assembled by Joseph Fry from the collection of Manchester Museum.

This preservation method is reminiscent of the old original technique developed in the late 17th century by James Petiver (1663–1718), known as ‘*the father of British butterflies*’ (Salmon 2000: 103), who preserved his specimens in between thin sheets of mica. At the beginning of the 20th century, other similar preservation methods were suggested: *e.g.*, the ‘Riker mount’ invented by Clarence Riker (1902), a shallow box in which the specimen is clamped between a transparent cover-plate and an elastic bed; or the flat mounts invented by Ximena McGlashan *et al.* (1915) in which an insect is fixed inside a secured, transparent closure by means of a wire holder. Compared to the Wooff technique, both these methods allowed a whole animal to be preserved in a transportable way. A similar preservation method was also patented by Karl Deubel (1938), who suggested coating the butterfly wings with clear lacquer, thus covering them with a transparent film, and then mounting them on any kind of material, including cardboard and paper. Despite its superficial similarity to Wooff’s technique, Deubel’s method was primarily aimed at ‘*decorating or embellishing numerous articles, or to form pictures, and find ready use in the manufacture of numerous articles*’.

Although the Wooff preservation method is not common, lepidopterists continue to use it. Roger Dennis (pers. comm.) recalled Wooff showing his technique to M.E.S. members, and in the mid-1980s to the early 1990s several M.E.S. members adopted it. For instance, Michael Cooper who had ‘*some wings of Papilio alexanor from Turkey preserved in this way*’ (Peter Hardy, pers. comm.), E.H. Fielding who may have also used this technique for recording hoverflies (Syrphidae), Roger Dennis who produced a voucher set of moths on card for identification or learning purposes to facilitate UV recording, and others.

Today, the Wooff method is still in use. Stephen Hind, the current Cheshire County recorder for Lepidoptera, assembled a reference collection of wing mounts consisting of 964 cards of 1093 specimens (Figs 12–13): micro-moths (747 cards, 834 ex), macro-moths (185 cards, 222 ex), butterflies (4 cards, 4 ex), and even Diptera (mainly Tephritidae; 28 cards, 43 ex). His collection also includes 890 photos (884 micro-moths, five macro-moths and one butterfly) that are mixed in with the wing mounts, and sometimes photos depict the specimens which were mounted (Stephen Hind, pers. comm.). He learnt and adopted this preservation method from Charles Ian Rutherford (1919–2008), his predecessor as a County Lepidoptera Recorder for the vice-county of Cheshire (see Wallace 2012) and also the former member of M.E.S., who in his turn might have learnt it from R. Wooff. It is worth noticing that in all the aforementioned examples of contemporary use of wing mounts, the collections have been primarily/only used for reference purposes (*viz.*, identification and learning).

Others have devised techniques along similar lines. Quidort (2017) describes the method adopted by him for educational use with farmers and students, which mounts the wings of Lepidoptera on white card and then seals them between two layers of clear plastic. These ‘laminations’ also have the advantage of flexibility, so reducing the possibility of damage from bending. As with the Wooff method, additional information can be added to each card before lamination. A more elaborate method has been devised by researchers from the University of Maryland and the Florida Museum of Natural History (Cho *et al.* 2016). Their method preserves the right hand side of each forewing and hindwing of any Lepidoptera by laminating the wings to a card or holding them within a coin holder pack. They preserve the other two wings and the body for subsequent DNA extraction and analysis. Of course, all these

systems, including that of Wooff, were never intended to replace the traditional (pinned) natural history lepidopteran collections in museums, which remain the standard for curatorial practice and taxonomic research.

Outside collecting practice and research, laminated butterfly wings are commonly used in art and crafts. Wings are thermally laminated between two pieces of clear plastic making them visible from both sides, and then cut out leaving a little border around the edge. Such laminated wings, which sometimes are either embedded in resin or attached to pieces of mica/glass, are commonly used for fairies, scrap-booking, ornaments, jewellery, collage, etc. (e.g., Anon 2015; McGovern 2014). In the USA, a patent exists (Soukup 2006) on a multi-layer butterfly wing lamination process to facilitate their use in jewellery, gift items and crafts (*cf.* Deubel 1938).

Collections of wings of other insect groups are not that uncommon in natural history museums, though entomologists assemble them for various reasons. For instance, a collection of some 750 glass-slide-mounted Diptera specimens is retained in the Buckinghamshire County Museum (Mike Palmer, pers. comm.). This collection mostly consists of pairs of fly wings, although some whole bodies are also present (Fig. 14). The collector, Cecil Monk (d. 2004), was a professional and keen microscopist (Anon 2004) and hence utilized the preservation method that best suited him. It is a bit unclear why wings were not mounted together with the corresponding fly body on the same slide. These slides are accompanied by five ring-binders containing detailed paper records and drawings for each slide. Thus, the collection is indeed of a high scientific value regarding flies of the Chesham area (UK), though it is an unusual (for Diptera) preservation method.

Manchester Museum also holds a collection of 84 microscope slides of Lepidoptera wings and scales (Fig. 15) that were assembled by Joseph Fry in the 1860's. Many slides in this collection were mounted by W.H. Heys.

CONCLUSION

The following analysis of the Wooff collection is based on the three collection sections described above: Afrotropical, New World and European. The numbers in each section vary. The Afrotropical collection was made when he was working in Uganda between 1958 and 1972 and then added to when he returned to Africa in the 1990s. The New World collection was effectively created as a result of a single visit to Costa Rica in 1997. The European collection was assembled from specimens accumulated from dealers and other collectors who obtained their specimens between 1890 and 1939 and then peaked when he was collecting as a university student and postgraduate researcher. He then added to his collection when he returned to England from Uganda in 1972.

We found that the specimens in the Afrotropical and New World sections were all butterflies and were almost exclusively caught by Wooff himself, whereas he caught less than half of his European stock. We found that ♂/♀ ratios in both the Afrotropical and New World collections were similar but the species/specimen proportion in the New World section (0.38) was higher than that in the Afrotropical one (0.15). This was due to the fact that the location of the collecting sites for the former was Costa Rica which has a much higher species diversity (DeVries 1983). For both the Afrotropical and the New World sections the number of specimens reared was small, being 6 and 0 respectively. The other major difference between the

two collections was that whereas some 80% of the New World was caught in one decade the Afrotropical collection was caught over six decades.

The Wooff European collection is composed of both butterflies and macromoths, there being roughly four times as many macromoths as there are butterflies and the focus is on British species (Table 4). The British fauna of butterflies is around 70 species (Thomas & Lewington 2010) and of macromoths is around 900 (Waring & Townsend 2009). Thus, the Wooff collection of 60 species of butterflies (c. 85% of the total) is quite comprehensive, but the number of macromoths (272 species; c.30% of the total) is less so. The percentage of female and male butterflies and moths were found to be similar (Table 4), as were the percentages of each that were caught. However, the percentage of reared butterflies and moths were different, with twice as many moths being reared as butterflies. This was possibly due to the ease with which mated female macromoths lay eggs in either a moth trap or if transferred from the trap to an enclosed container.

Although Wooff collected similar percentages of butterflies and moths himself his collection was aided by a number of other collectors (Tables 1, 4), in particular by E.H. Fielding and J.P. Robson. Both were well-known collectors, with Robson in particular making a major contribution to the number of macromoths. Not only did Robson provide many moths for Wooff, for example, 24 of the 33 specimens of Large Thorn (*Ennomos autumnaria*), eight of the 16 specimens of Coxcomb Prominent (*Ptilodon capucina*) and seven of the 14 specimens of the Alder Moth (*Acronicta alni*), he also took them in several different counties of Britain (Kent, Berkshire and Hampshire, respectively; Table 6) well beyond his home county of Durham. So Robson travelled widely to collect eggs, larvae and adult macromoths. We found that Robson also seemed to specialise in the rearing of macromoths as he provided twice as many moth specimens as butterflies to Wooff.

The Wooff European collection was also assembled over a longer period for moths than for butterflies. We feel that this is probably explained by the fact that two of the key contributors, Fielding and Robson, were both actively collecting butterflies and macromoths prior to Wooff and so they were able to provide him with the specimens he needed. This is not to say that Wooff was not indebted to other dealers who may have provided only a few, but perhaps crucial, species of macromoths. For example, all four specimens of Scotch Burnet (*Zygaena exulans*) in the collection were supplied by A.J. Showler. The moths were caught by him at Braemar, Grampian in July 1955. The atlas of UK macromoths (Hill *et al.*, 2010) shows the moth is only found in three 10×10km grid squares in the Grampians. Similarly, both specimens of Barrett's Marbled Coronet (*Hadena luteago barrettii*), a species found in the SW Peninsula and in SW Wales, were supplied by another British collector, F.C. Woodford. These were caught in Bude, Cornwall in June 1917. It would be interesting to compare the percentages of macromoths supplied by these collectors to other collections in Manchester Museum (if any), or museums elsewhere, but this information is not yet available.

The three sections of Raymond Wooff's lepidopteran collection provide an insight into one British researcher and collector of moths and butterflies who was able, largely through his own industry, enthusiasm and tenacity, to put together an impressive assemblage of lepidopterans using his distinctive system of preservation (see above; Figs 5, 7, 9–11). Furthermore, his collection is impressively data-rich and thus is a reliable source of information on distribution, habitat preferences and phenology of the majority of the collected species for the benefit of

professional/amateur lepidopterists and users/researchers of any (inter)national recording scheme.

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