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An overview of Lepidoptera-host-parasitoid associations for southern Africa, including an illustrated report on 2 370 African Lepidoptera-host and 119 parasitoid-Lepidoptera associations

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Abstract: We present an overview of the known host associations of larval Lepidoptera for southern Africa, based on a database of 11 628 rearings, including all Caterpillar Rearing Group (CRG) records and other published records. Rearings per Lepidoptera family show some bias in the rearing effort towards the more conspicuous families, ectophagous groups and non-detritus-feeders but in general follow species diversity. Recorded Lepidoptera host associations per host family for southern Africa are shown. Data analyses revealed the following general trends: of the 20 most reared species 13 are polyphagous; Fabaceae are the most utilised plant family with 2 122 associations, followed by Asteraceae (600), Malvaceae (564) and Anacardiaceae (476); 98.8 % of hosts are vascular plants; and of the 19 most utilised host species 18 are common trees or shrubs. We discuss possible reasons behind these trends, particularly the high utilisation of Fabaceae and the widespread use of trees and shrubs as hosts. We compare recorded host species numbers with species diversity for the 19 most recorded host families and discuss possible reasons for the low utilisation of four plant families with an exceptionally low percentage of Lepidoptera host species / plant host species diversity. All Lepidoptera families for which more than 100 rearings have been recorded (21 families) utilise one (or two in the case of Pyralidae, Nolidae and Hesperiidae) plant family exponentially more than any of the other families, with resulting histograms forming hyperbolic curves, as are typical of distributions of taxonomic assemblages in nature. We calculate an exponential factor to quantify this phenomenon and show that for all 21 Lepidoptera families one host family is utilised 6–33 times more than the average use of other host families. In this paper, the larvae and adults of 953 African, mostly South African, Lepidoptera species reared by the CRG between January 2016 and June 2019 are illustrated together with pertinent host information. 119 Lepidoptera-parasitoid associations are reported, comprising seven hymenopteran families and one dipteran family. With the current data release, larval host association records are now available for 2 826 Lepidoptera species in the southern African subregion, covering about 25 % of the described fauna.

Key words: Lepidoptera, Hymenoptera, Diptera, caterpillar, larva, moth, butterfly, South Africa, Africa, Afrotropical region, pupa, host, life-history, host-use, host-specialisation, parasitoid.

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INTRODUCTION

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Plants, insect herbivores and their arthropod parasitoids and predators constitute over 75 % of all multicellular diversity of terrestrial life on earth (Price, 2002). All three are crucial for ecosystem functioning. The effect of disruption of the ecological balance at these trophic levels can be clearly seen in the devastating impact of alien invasive species across the globe (Vilá *et al.*, 2011). Yet even fundamental knowledge on ecological interactions at these three trophic levels for the Afrotropical region is largely lacking.

A compilation of Lepidoptera-host associations recorded for southern Africa (including all published records to date) conducted in 2012 registered such associations for less than 7 % of the Lepidoptera species in southern Africa and for only a handful of Lepidoptera-parasitoid associations (Staude & Kroon, 2012). To address this problem, at least for Lepidoptera-host-parasitoid interactions, the Lepidopterists' Society of Africa (LepSoc Africa) launched a successful citizen science project called the Caterpillar Rearing Group (CRG), details of which can be found in Staude *et al.* (2016a). The CRG compiles selected rearing data into master lists, each representing a major Lepidoptera taxonomic group. The main purpose of the master lists is to create a vehicle by which this large and growing set of life-history data can become accessible to other users, from scientists to conservationists, naturalists and other parties.

Parasitoids are defined by their behaviour of ultimately killing their hosts (Price, 1975; Godfray & Godfray, 1994; Mills, 2009; Quicke, 2015). It is usually the larval stage of the parasitoid that attacks the host invertebrate (usually the immature stages), whereas the adults are free-living (Vinson, 1976; Godfray & Godfray, 1994). In contrast to true parasites, which do not kill the host, parasitoids only require a single host to develop into adults (Price, 1975; Godfray & Godfray, 1994). In the class Insecta, several orders are known to include parasitoid species (Coleoptera, Diptera, Hymenoptera, Lepidoptera, Neuroptera, Strepsiptera and Trichoptera), with ca. 10 % of described insect species being parasitoids (Price, 1975; Mills, 2009). This is the first time that we report on parasitoid-Lepidoptera associations. Although many more parasitoids have been reared by CRG members, only 119 parasitoid-Lepidoptera associations have been processed and are dealt with in a preliminary manner here at family level, prior to undergoing further identification of the parasitoid species.

The first CRG publication reported on 1 778 rearings comprising 962 species of Afrotropical Lepidoptera (Staude *et al.*, 2016a, 2016b). The second CRG publication reported on another 458 rearings comprising 424 taxa of Afrotropical Papilionoidea (Congdon *et al.*, 2017). We present master lists on a further 2 370 rearings, comprising 953 species of Afrotropical Lepidoptera and adding an additional 641 species to the total number reared, thus bringing the total of Lepidoptera represented in the CRG master lists to 2 027 species.

Kroon (1999) published lists for Lepidoptera-host associations known at the time, but no overview of the state of knowledge of Lepidoptera-host associations for southern Africa had been published before. We here present such an overview of our knowledge of Lepidoptera-host associations for southern Africa based on the rearing efforts of CRG members as well as other published Lepidoptera-host associations included in our main database of such associations. We briefly discuss new insights emerging from this dataset.

MATERIAL AND METHODS

This paper reports on rearings made by CRG members during the period of January 2016 – June 2019, as well as on rearings conducted at an earlier date but which were not included in the previous papers for various reasons (e.g. late submission to the project).

Comprehensive details of the methods employed by the CRG were published in Staude *et al.* (2016a), which remain the same for this publication (unless otherwise stated below), and only a shortened version is presented here.

Terminology

The terms 'caterpillar' and 'larva' are used interchangeably in this article, although they are not fully synonymous. 'Larva' (plural: larvae) is the technical term for the life stage of any holometabolous insect between egg and pupa, whereas 'caterpillar' is a vernacular term for the (generally free-living) larvae of moths and butterflies (Lepidoptera) as well as those of sawflies (Hymenoptera). The rearing efforts of the CRG do not cover the caterpillars of sawflies, however.

The term 'host' is relative and depends on the context in which it is being used in the text. A Lepidoptera 'host' refers to the source organism of the food used by the Lepidoptera larva. This is usually a living plant, but it may also be other living organisms or their detritus. A parasitoid 'host' is the lepidopteran taxon from which the parasitoid was reared, generally its egg, larval or pupal stage. Parasitoids also use many other organisms as hosts but in the context of this paper it refers to Lepidoptera.

The term 'rearing' refers to a rearing event in which a larval host association was established by observation that the larva was feeding on the host. The rearing of multiple conspecific caterpillars from the same host and same locality at the same time constitutes a single rearing. When a single lava was reared on multiple host species, these were treated as separate rearings, with the host on which the larva was found in the field regarded to represent a natural host association and the others as established only in captivity.

The term 'master lists' refers to lists compiled by the CRG containing pertinent data for each rearing received from members, including: unique rearing number; Lepidoptera species, subfamily and family; host species and family; locality; collecting date, pupation date, eclosion date; rearer name; photograph of final-instar larva; photograph of adult.

The term 'main database' refers to a database of Afrotropical Lepidoptera-host associations kept by the first author, which includes all CRG records, all records published by Kroon (1999), records extracted from specimen label data and other published records (Fig. 1). There is a wealth of additional published rearing information available for the Afrotropical Region outside of the southern Africa subregion, but most of this has not yet been included in the database. The current database, however, is deemed to be a comprehensive list of the known Lepidoptera larval host associations for the southern Africa subregion. The term 'southern Africa' comprises South Africa, Lesotho, eSwatini, Botswana, Namibia, Zimbabwe and Mozambique south of the Zambezi river.

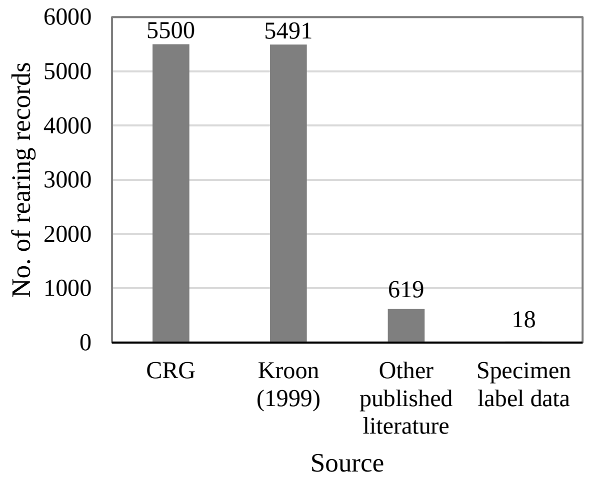

Figure 1 – Source of rearing records in the main database of African Lepidoptera-host associations (n = 11 628).

Approach and protocol

Members of the public were and still are invited to rear the larvae of African Lepidoptera and keep records of the rearings. They are encouraged and guided to rear eggs and larvae of moths or butterflies they come across to adulthood, to photograph all life stages and hosts as well as parasitoids, to record all observations, to preserve voucher specimens of the reared moth or butterfly as well as of the host and any parasitoids, and to submit the records and vouchers to the CRG management team. The following minimum information is required with each submission, generally by e-mail to the CRG management: locality description including longitude and latitude, name of host if available, date of collection of life stage, date of pupation, date of emergence of adult, photographs of caterpillar, pupa, adult, host and parasitoid. Notes on interesting observations may also be submitted. All photographs and data submitted are electronically stored by CRG management under the names of the individual contributors. At the time of writing, more than 66 500 photographs and documents have been received for safekeeping.

Collating the rearing records into master lists

The main current output of the CRG is the master lists, comprising rearing records of Afrotropical Lepidoptera submitted by CRG members.

Identifications of Lepidoptera and parasitoid taxa are based as far as possible on available voucher specimens. Bombycoidea are identified or confirmed by R.G. Oberprieler and all other Lepidoptera are identified, or rearer identifications confirmed, by H. S. Staude, unless otherwise stated in the master lists where determinations were made by taxon specialists. Hymenoptera are identified by Simon van Noort unless otherwise stated. The parasitoid wasps covered in this article were identified based on photographs submitted by the rearers but will be verified once the voucher specimens have been examined.

Identification of host species are mostly provided by the individual rearers using the many excellent illustrated field guides that are available for South African plants. These were checked as far as possible by M. Maclean. Many vascular plants that were difficult to identify were posted on iNaturalist (www.inaturalist.org), where they were identified or their identification confirmed by experts. Dried herbarium specimens were kept in many cases where plants could not be identified.

For parasitoids, the CRG management team is currently in the process of preparing voucher specimens for submission to taxon specialists for identification. The Hymenoptera will be photographed at high resolution at the Iziko South African Museum and their data added to WaspWeb (www.waspweb.org), the online resource for information on wasps, bees and ants of the Afrotropical biogeographical region. So far we have not found a taxon specialist for African dipteran parasitoids.

The classification of the Lepidoptera largely follows Nieukerken *et al.* (2011) and Krüger (2020). Data in the tables regarding Lepidoptera species diversity for southern Africa were similarly extracted from Krüger (2020).

Plant names and classification follow the portal *Plants of the World Online* (www.plantsoftheworldonline.org) for the vascular plants (Spermatophyta), in collaboration with the South African National Biodiversity Institute (SANBI). For the non-vascular plants and fungi, we do not have specific authorities, taxon specialists or voucher specimens, and most of these remain identified only at higher ranks.

The localities recorded in the master lists refer to the place of collection of the specimen, from which the rearing commenced, be it an early stage (usually egg or larva) or an adult female that laid eggs.

Blank cells in the master lists mean that we have been unable to identify the specimen to the denoted taxon level.

The tables and information presented in the overview of Lepidoptera-host associations for southern Africa are based on the main database.

Storage of submitted material

CRG members are encouraged to preserve and submit voucher specimens of reared pupae, adults, hosts and parasitoids to the project team. Adult Lepidoptera specimens, when received, are mounted and labelled in the standard way for Lepidoptera (Richardson, 2015) and initially stored in the Staude Collection (private collection of H.S. Staude housed in Magaliesburg, South Africa). Subsequently, the specimens are, when possible, donated to taxon specialists for confirmation of species identifications in the master lists and for further taxonomic work.

Parasitoids are initially stored in ethanol vials in the Staude Collection. The Hymenoptera are then transferred to the Iziko South African Museum for identification and permanent storage. The Diptera are transferred to Johan Pretorius who will distribute them to taxon specialists for identification when such have been found.

Pressed plant specimens received are similarly initially kept in the Staude collection until a more suitable herbarium depository for them can be found.

RESULTS & DISCUSSION

During the period of this report (January 2016 – June 2019), 2 370 submissions comprising 953 Lepidoptera species were made by 59 CRG members (individuals or teams) and processed by the CRG management. These are presented here as 28 CRG master lists (pages 21–380) and should be regarded as an addition to the CRG master lists published by Staude *et al.* (2016a,b) and Congdon *et al.* (2017). The contributions made by each member or team for this latest batch are shown in Table 1 (page 11). The explanation to the master lists is given on page 20.

The total CRG master lists currently contain 4 524 valid rearings comprising 3 275 different host-associations for 2 027 putative species of Afrotropical Lepidoptera. Host associations have been recorded for the first time for at least 652 species, not including the many specimens that could not be identified to species level, often due to a lack of expertise but mostly due to an unresolved taxonomy.

The main database contains records of 11 628 rearings of Lepidoptera-host associations. For southern Africa, Lepidoptera-host associations are now available for some 2 815 putative species, comprising ~25 % of the described Lepidoptera fauna (10 839 species), effectively more than doubling the proportion of about 7 % estimated in 2012 (Staude & Kroon, 2012).

CRG parasitoid rearing submissions

To date, we have processed 119 parasitoid rearing submissions. Of these, 27 % (n = 32) are records of true flies (Diptera) and 73 % (n = 87) are records of wasps (Hymenoptera). The high number of Hymenoptera submissions comes as no surprise, as this order contains ca. 77 % of all known insect parasitoids (Mills, 2009).

The most important families of hymenopteran parasitoids are Braconidae, Chalcididae and Ichneumonidae (Quicke, 2015). From the records reviewed thus far, seven hymenopteran families were found to parasitise 14 lepidopteran families (Table 2: page 12). Of these, about 23 lepidopteran species and three hymenopteran species have been identified so far.

For the dipteran parasitoids, the family Tachinidae appears to represent all submissions received, pending further confirmation by taxon specialists. The family constitutes one of the largest families of Diptera, and all known species are endoparasites of insects (and sometimes of centipedes) (Barraclough & Londt, 2008). From records received to date, eight lepidopteran families were parasitised by flies (Table 3: page 13). Of these, 14 lepidopteran species have been identified.

Six lepidopteran families (Erebidae, Geometridae, Lasiocampidae, Noctuidae, Notodontidae and Pieridae) acted as hosts for both flies and wasps, and seven subfamilies (Ennominae, Erebinae, Heliothinae, Lasiocampinae, Lymantriinae, Pierinae and Plusiinae) were common hosts of both dipteran and hymenopteran parasitoids (Tables 2 and 3).

It is expected that parasitoids could attack all lepidopteran species, but a sustained rearing effort would be required to eventually obtain a more comprehensive record of parasitoidism. Hundreds of parasitoids have already been reared by CRG members, but these still need to be identified and processed.

A brief overview of the state of knowledge on Lepidoptera-host associations for southern Africa based on the main database

Establishing host associations for Afrotropical Lepidoptera is a huge task considering the size of the region and the incredible diversity of Lepidoptera and vascular plants that the region contains. The database is overwhelmingly biased towards the southern Africa subregion (Table 4: page 13). Figure 2 shows a map of rearing localities (where location data are available). This bias is due to the fact that most CRG members reside in southern Africa, but also because most of the host associations available in the published literature for the rest of the Afrotropical region have not yet been captured in our database. The following results, therefore, are an attempt at providing a brief overview of our current knowledge for southern Africa only, based on the main database.

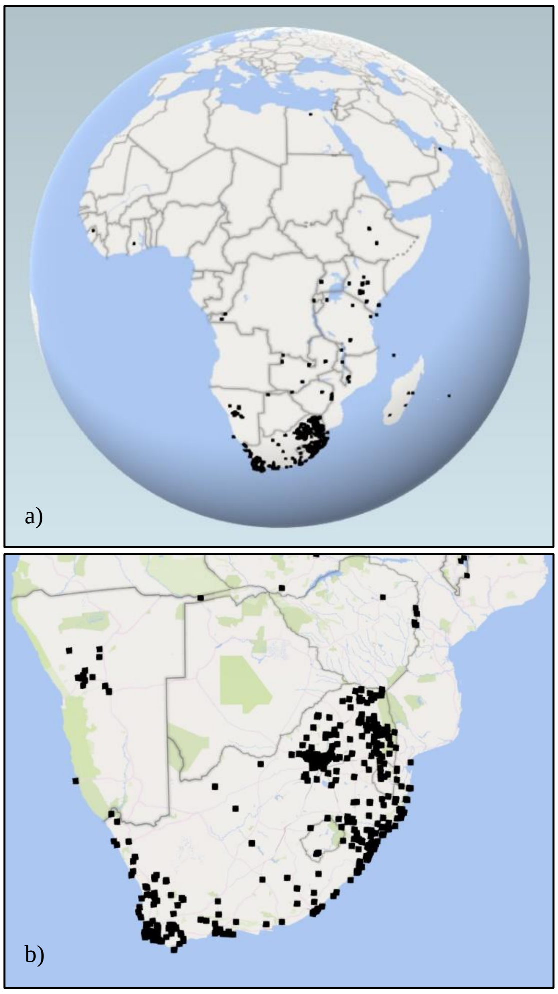

Figure 2 – Maps of a) the Afrotropical region and b) southern Africa, depicting locations (where known) of recorded Lepidoptera-host associations (n = 4 478 rearings).

Host associations for southern Africa were recorded for 66 Lepidoptera families (Table 5: page 14). For 24 rearings the Lepidoptera family could not be identified and for 565 rearings specimens could not be identified to species level. The main database now has records for 2 826 identified Lepidoptera species, of which 1 439 are from the CRG.

Table 6 compares the number of recorded host associations to species diversity for the most represented 19 Lepidoptera families for southern Africa. As can be expected, the well-known showy families attracted a high percentage of rearing effort compared to species diversity (Papilionidae 623 % and Saturniidae 642 %), whereas the less showy families showed a much lower percentage (Gelechiidae 27 % and Pyralidae 34 %). The relatively high percentage for Tortricidae (79 %) is probably due to the poorly worked taxonomy for the family in southern Africa, with many known undescribed species.

Table 6 – The number of Lepidoptera-host associations (rearings) per Lepidoptera family for southern Africa compared to the number of species comprising each Lepidopteran family (species diversity) for the 19 Lepidoptera families with the most number of rearings (n = 10 106).

Family	No. of rearings	No. of species	% rearings/ species
Erebidae	1 769	1 565	113
Geometridae	1 621	1 531	106
Lycaenidae	1 063	509	208
Noctuidae	972	967	101
Nymphalidae	852	324	263
Saturniidae	520	81	642
Sphingidae	511	111	460
Lasiocampidae	486	227	214
Hesperiidae	339	155	219
Crambidae	296	526	56
Pieridae	286	64	447
Notodontidae	246	225	110
Tortricidae	236	298	79
Pyralidae	215	630	34
Gelechiidae	160	597	27
Gracillariidae	159	175	91
Nolidae	149	159	94
Papilionidae	137	22	623
Nepticulidae	89	125	71

The 20 most commonly reared Lepidoptera species are shown in Table 7 (page 15). The African Bollworm, *Helicoverpa armigera*, recorded from 136 host-plant species belonging to 39 plant families, is by far the most encountered species. Eleven of the 20 species on this list utilise 10 or more host families. By contrast, *Chiasmia brongusaria* and *Cabera strigata* utilise only one host family.

Recorded Lepidoptera-host associations per host taxon (mostly family) for the southern Africa are shown in Table 8 (page 15). Host associations were recorded for 174 vascular plant families. Over 2 600 host taxa could be identified to at least the genus level. Only 128 (1.2 %) of the 10 981 host associations recorded were for non-plant species, confirming that the vast majority of Lepidoptera are indeed phytophagous. Fabaceae is by far the family of vascular plants most utilised by southern African Lepidoptera, with 2 122 associations recorded. The next most-utilised families are Asteraceae (600), Malvaceae (564) and Anacardiaceae (476).

The 19 plant species most commonly utilised by Lepidoptera are shown in Table 9 (page 17). The three most frequently used host species are: *Vachellia karroo* (Fabaceae) with 356 associations of 158 Lepidoptera species; *Gymnosporia buxifolia* (Celastraceae) with 144 associations of 67 species; and *Ziziphus mucronata* (Rhamnaceae) with 115 associations of 48 species. All three of these species are common trees that are widespread across southern Africa. The high utilisation of the Australian wattle *Acacia mearnsii* is probably an indication that the secondary defensive metabolites produced by this species are not very different from those produced by the closely related local Acacieae, making the host shift to this exotic species rather easy. This exotic species is also now common and widely distributed throughout southern Africa.

With the exception of *Ehrharta erecta* (Poaceae), all the vascular plants on this list are widespread common shrubs or trees. All the records for *E. erecta* are for Hesperiidae and Nymphalidae. It is probable that this plant is on the list of the 20 most utilised vascular plants because of rearings from eggs under artificial conditions by Lepidopterist specialists, rather than representing natural host associations, or it may be due to erroneous reporting in the literature, where the text "*Ehrharta erecta* and other grasses" is repeatedly used for most grass-feeding species.

The data suggest that widespread trees and shrubs with a large individual biomass are particularly prone to being used by Lepidoptera as hosts, but this could also be a case of the under-sampling by caterpillar rearers on herbaceous vascular plants, which are often more difficult to sample.

Table 10 (page 17) compares recorded host associations and 'recorded host species' to 'host species diversity' for the 19 most utilised host families for southern Africa. In this comparison the percentage of associations per species diversity for Fabaceae was rather low (34 %, comprising only 5.6 % of the flora), indicating that many Fabaceae species have probably not yet been sampled for Lepidoptera herbivory, possibly because of the many localised herbaceous species in this family. This is the case as well for the other plant families on the list, providing an indication of how much there is to do and that under-sampling is still a major problem.

Plant families with an exceptionally low percentage are highlighted with an asterisk (Table 10: page 17). For Apocynaceae (8 %) and Euphorbiaceae (15 %) the reason for the low utilisation by Lepidoptera can probably be ascribed to their known numerous well developed defensive secondary metabolites (see Livishultz *et al.* (2018) for Apocynaceae; and Mwine & Van Damme (2011) for Euphorbiaceae).

Poaceae (13 %) are well known for their structural defensive mechanisms, incorporating abrasive silicates into their leaf cells (Kaufman *et al.*, 1985), which seems to prevent their utilisation as food by major Lepidoptera groups and probably contributes to the low percentage found here. For instance, there are no records of any Geometridae (the second-most diverse Lepidoptera family) utilising Poaceae as hosts in our database (Staude *et al.*, 2019).

A contributing factor in Africa could be the grazing pressure on Poaceae from large mammals. Caterpillars run a high risk of being eaten by these grazers and appear to need particular defensive strategies to be able to feed on grasses, such as having urticating spines (as in the saturniid *Decachorda*, the lymantriine *Psalis africana* and some Eupterotidae) or being large and spiny and feeding only on large grasses (the saturniid *Bunaeopsis*) or feeding only at night (many Eupterotidae and Noctuidae) or feeding low down near the root base where grazers do not reach (Crambinae).

Some collecting bias should also not be disregarded, as no rearings are recorded for Crambinae in the data, which are well known to feed on grasses in other regions.

The low percentage for Asteraceae (16 %) is more difficult to explain and may be an artefact of under-sampling as most vascular plants in this family are low-growing herbs that make it difficult to find caterpillars. It is expected that a concerted effort by CRG members to look for caterpillars on Asteraceae will reveal many interesting new associations.

The highest percentage (115 %) is for Loranthaceae and reflects the extensive work done in the past on the life histories of the Theclinae (Lycaenidae) (Congdon *et al.*, 2017), which represents a single radiation, and this work has evidently inflated the data abnormally.

A further interesting result is that most Lepidoptera families seem to utilise one (or two in the case of Pyralidae, Nolidae and Hesperiidae) plant family exponentially more than any of the other families. For example, Geometridae use 91 plant families as hosts but use Fabaceae exponentially more than any other family (Table 11), and Pieridae utilise 23 plant families but use Capparaceae exponentially more than the rest (Table 12).

In order to quantify this phenomenon, of a host family being utilised exponentially more than others, we calculated an exponential factor (A) using the formula A = D / (B - D) x E, where B = records for Lepidoptera family, D = records for host family, E = host families recorded for Lepidoptera family. Table 13 (page 18) shows this exponential factor for all the Lepidoptera families in southern Africa for which our dataset contains more than 100 rearing records (L100). This exponential factor quantifies the exponential nature of host family usage for a given Lepidoptera family. For instance, in Erebidae, Fabaceae are used 33 times more than the average use of the their other host families.

Table 11 – Recorded Geometridae-host associations per host plant family, for the 27 most used families (n = 1 380).

Plant family	No. of rearings		Plant family	No. of rearings
Fabaceae	438		Santalaceae	17
Celastraceae	184		Icacinaceae	14
Anacardiaceae	100		Primulaceae	14
Rhamnaceae	97		Sapindaceae	14
Asteraceae	95		Stilbaceae	13
Rubiaceae	76		Ochnaceae	12
Proteaceae	46		Phyllanthaceae	12
Combretaceae	36		Rosaceae	12
Ericaceae	35		Asparagaceae	11
Zamiaceae	28		Ebenaceae	11
Ranunculaceae	26		Myrtaceae	11
Oleaceae	20		Plumbaginaceae	11
Loranthaceae	19		Stangeriaceae	11
Euphorbiaceae	17			

Table 12 – Recorded Pieridae-host associations per host plant family (n = 285).

Plant family	No. of rearings		Plant family	No. of rearings
Capparaceae	159		Lauraceae	1
Fabaceae	37		Moraceae	1
Brassicaceae	30		Olacaceae	1
Loranthaceae	13		Oleaceae	1
Salvadoraceae	11		Phyllanthaceae	1
Santalaceae	6		Polygonaceae	1
Celastraceae	5		Resedaceae	1
Clusiaceae	4		Rhizophoraceae	1
Poaceae	4		Rosaceae	1
Apocynaceae	2		Sapindaceae	1
Asteraceae	2		Tropaeolaceae	1
Euphorbiaceae	1			

The fact that this pattern applies to all 21 Lepidoptera families and is derived from a dataset of 11 055 records accumulated across the subcontinent over many years by more than 150 rearers, who were not subjected to any standardised sampling method, suggests that this phenomenon is not an artefact of sampling bias but real. When these host usages are plotted in numerical sequences (Figs 3ab, 4), the resulting histograms form hyperbolic or 'hollow' curves, as are typical of distributions of taxonomic assemblages in nature (e.g. Willis & Udny Yule, 1922; Dial & Marzluff, 1989; Scotland & Saunderson, 2004; Richardson & Oberprieler, 2007). This common, non-random distribution is evidently a true and universal evolutionary pattern that appears to reflect the fractal geometry of taxic diversity (Burlando, 1990) and seems largely related to the division

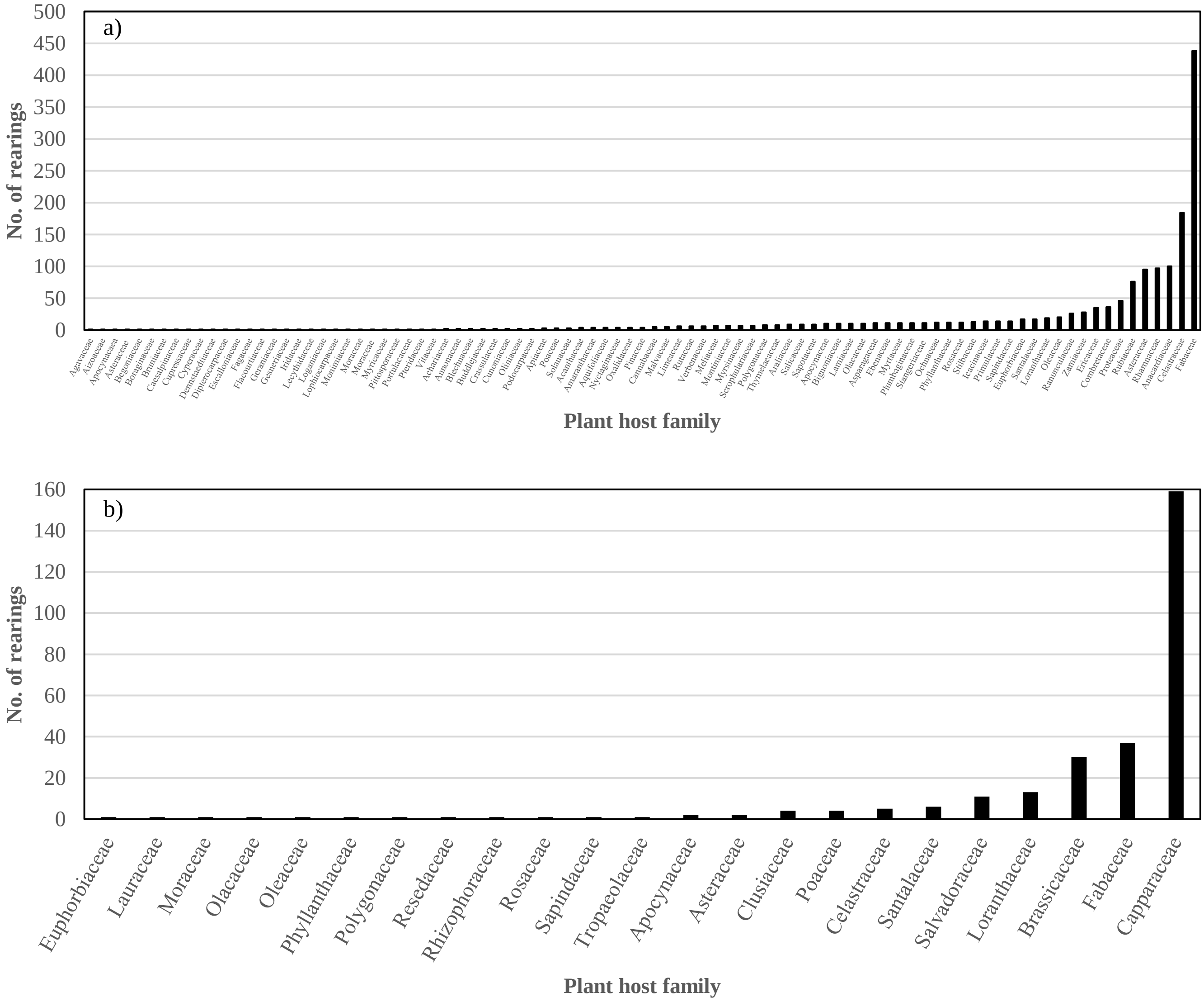

Figure 3 – Graph of a) Geometridae-host associations (rearings) for all 91 host families (n = 1 597 rearings) and b) Pieridae-host associations per plant family (using data in Table 12; n = 285 rearings), showing the hollow curve phenomenon for a family that utilises one host family exponentially more than others.

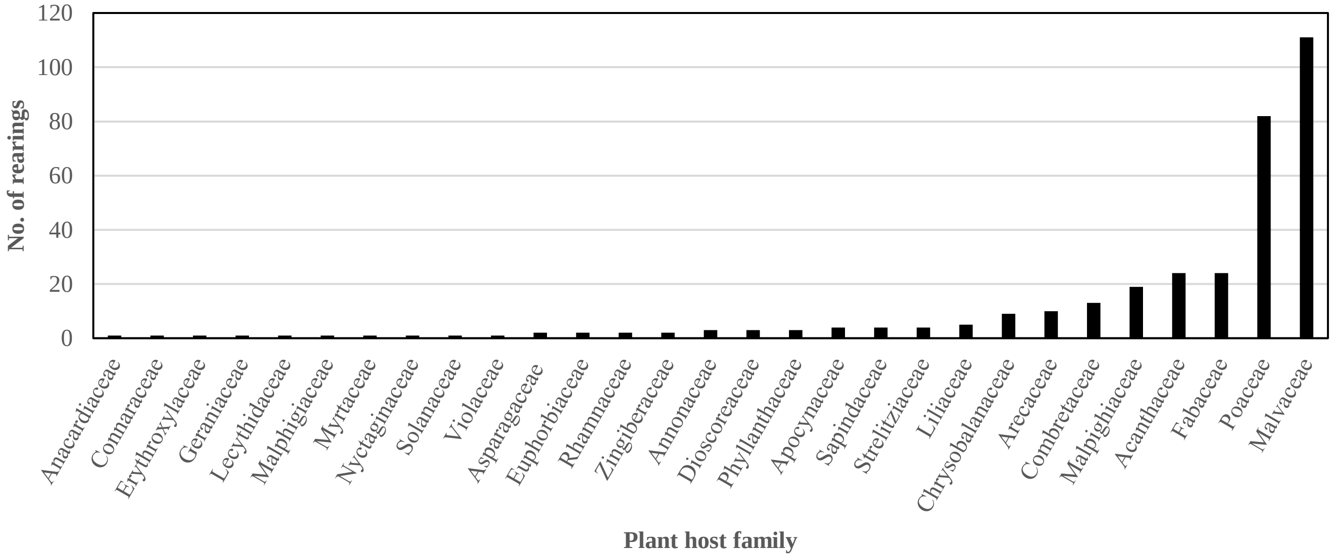

Figure 4 – Graph of Hesperiidae-host associations (rearings) per plant family, showing the hollow curve phenomenon for a family that utilises two host families exponentially more than others (n = 336 rearings).

of ecological niche space available to diversifying lineages (Dial & Marzluff, 1989; Richardson & Oberprieler, 2007). Our data seem to confirm that taxonomic host usage of Lepidoptera follows this same evolutionary pattern.

For 12 of the 21 Lepidoptera families (L100), the recorded exponentially-used host family is Fabaceae. 747 Lepidoptera species have been recorded feeding on 359 species of Fabaceae in southern Africa (Table 10: page 17). The high species diversity of Fabaceae in southern Africa (6 374) may possibly explain the high utilisation of this family by Lepidoptera for the region, but this is unlikely because the recorded hosts comprise just 5.6 % of the diversity of the family in the region (Table 10: page 17).

A more likely factor for this pattern is the prominence of the family in terms of its common and widespread presence and large biomass across a large part of the southern African landscape (e.g. tribe Acacieae), coupled with the fact that Fabaceae may be more nutritious due to their well-known symbiosis with nitrogen-fixing bacteria, an important property in a generally nutrient-poor region. Edge & van Hamburg (2009) reviewed the frequent use of Fabaceae in myrmecophilous lycaenid larvae and found evidence of high content of essential amino acids. Many Poaceae also have associations with nitrogen-fixing bacteria, but the abrasive silicates they incorporate into their leaf structure and other ecological factors probably prevent many Lepidoptera from utilising them (as discussed above).

The usage of hosts within the Fabaceae by Lepidoptera is unevenly spread across the different lineages (Table 14: page 18). Of the 2 187 rearing records for the family, 929 (43 %) refer to the tribe Acacieae alone, which is significant seeing that these records span only 5.6 % of the Fabaceae species in the region (Table 10: page 17). Even though much more extensive sampling of Lepidoptera-Fabaceae associations is required before definitive conclusions can be reached about this pattern, it appears that the widespread utilisation of Acacieae is the main factor in the predominance of Fabaceae as larval hosts among the Lepidoptera fauna of southern Africa. This is unlikely to change radically when more data become available. Host usage is also uneven among the genera in the tribe Acacieae (Table 15), in that 59 % of the recorded host associations apply to the genus *Vachellia*, and this ratio increases to 69 % when the unnatural associations with the exotic genus Acacia are excluded. Furthermore, host usage is also greatly skewed in *Vachellia* (Table 16: page 19), in that 68 % of the recorded associations are with one species only, *V. karroo*, which thus emerges as the most extensively utilised host by Lepidoptera in southern Africa. The abundance and wide distribution of this species in the region is probably partly responsible for this pattern, but it may also be more palatable to Lepidoptera larvae in general than other species of the genus, and also than other species of the Acacieae and of Fabaceae overall. Nevertheless, the data show that even at the genus level one species is utilised exponentially more than any other and the same ‘hollow” curve is produced (Fig. 5) as those at the family level (Figs 3,4).

Table 15 – Recorded Lepidoptera-host associations per genus in the tribe Acacieae.

Genus	**No. of rearings**
Vachellia	548
Senegalia	168
Acacia	132
Undetermined to genus	81
Total	**929**

It would be interesting to compare host use of exponentially used host families in terms of biomass rather than species diversity, if such figures were available. Equally useful would be a comparison between host use and the secondary defensive metabolites these vascular plants produce.

CONCLUSION

This brief overview of Lepidoptera-host associations has produced more questions than answers, but it is hoped that this will stimulate further in-depth investigations into the intricate relationships between Lepidoptera and their hosts.

It is clear from the summaries of our data presented here that the distribution of host plant taxa among Lepidoptera needs to be investigated further, and further analyses are required to corroborate the patterns found here. This should include the addition of host records from other sources from other regions in Africa (e.g. the literature, notwithstanding its unreliability in many cases) as well as the more robust delimitation of lepidopteran taxa by means of phylogenetic methods (many are not demonstrably monophyletic, especially at the tribal level and below). Phylogenetic studies should also be able to elucidate the evolutionary history of host usage and host shifts (from ancestral to secondary hosts). It is our intention to incorporate the wealth of new information that modern molecular phylogenomics can bring in this regard into our database so as to enable further analysis of host patterns. This should be especially revealing once the phylogenetic positions of both the Lepidoptera and their hosts become better resolved between the family and genus levels.

The CRG has now entered its eighth year and has achieved much in the form of new data regarding the life-histories of southern African Lepidoptera. It has effectively doubled, in seven years, the amount of Lepidoptera-host associations that had been accumulated in more than a century before its inception in 2012. For the last few years now, new host associations are being accumulated at a rate of more than two per day by the CRG and it is hoped that this trend will continue in future.

The quality of the data is also much improved. CRG records have many advantages over traditional historical host records, which were often derived from *ab ovum* rearings in order to obtain good specimens for collections,

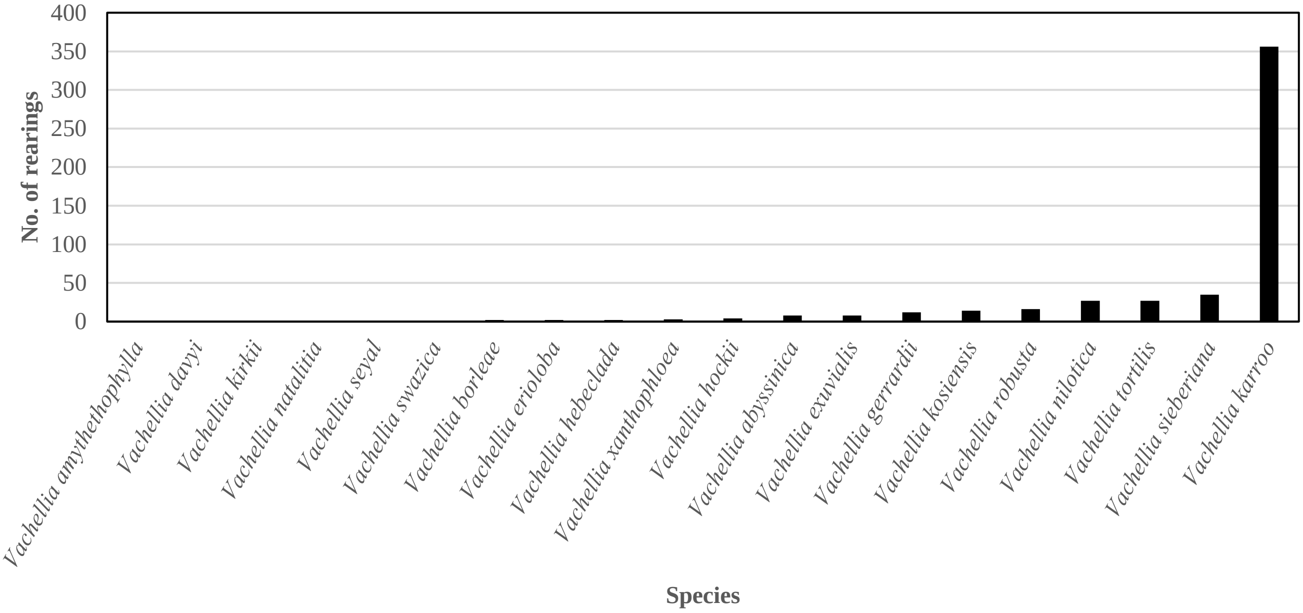

Figure 5 – Graph of Lepidoptera-host associations per species of *Vachellia* using the data in Table 16, showing the hollow curve phenomenon appearing at genus level.

thereby sometimes establishing artificial host-associations. These advantages are: female host choice in the wild is established; parasitoid associations are identified; exact geographical sampling locations are recorded; habitats at locations of sampling are often photographed; CRG members are spatially spread across the region; high-quality photographs of early stages are produced; fresh voucher specimens are frequently obtained and preserved for further study (including molecular analysis).

The resultant improved quality of the data and the rapidly accumulating CRG data in the main database will hopefully continue to enable better analyses and a better understanding of the vital intricate relationships between members of these three fundamental trophic levels upon which terrestrial life is reliant.

ACKNOWLEDGEMENTS

We thank first and foremost all our fellow caterpillar rearers for their contributions, as individually recognised in the master lists. Thanks are also due to our taxon specialists for identifying Lepidoptera in their sphere of expertise, who are likewise acknowledged at source. We thank the iNaturalist community (www.inaturalist.org) for supporting the CRG from its inception and for always being very helpful when plant identifications are required. Some of our active participants are from this community. Cape Nature, Ezemvelo KZN Wildlife, Isimangaliso Wetland Park Authority, South African National Parks, Northern Cape Nature Conservation, Eastern Cape Parks and Tourism Agency (ECPTA) and Limpopo Provincial Government are thanked for permission to collect caterpillars in areas under their jurisdiction. We thank Tony Rebelo and Ronel Kloppers for permission to use data contained in their unpublished plant list for southern Africa. We are grateful to the two peer reviewers, Konrad Fiedler and Axel Hausmann, who have chosen to make their identity known to us, for their very valuable comments and recommendations for future projects. These have greatly enhanced this article.

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Table 1 – Valid rearing contributions (n = 2 370 rearings) made by CRG members for the period January 2016 – June 2019.

Rearer/team	**No. of submissions**		**Rearer/team**	**No. of submissions**
A. Sharp & I. Sharp	997		A. du Plessis	1
H. S. Staude	573		A. Metcalf	1
J. Balona	126		A. Morton & E. Topp	1
S. Bradley	121		B. Jansen	1
M. Brink	87		C. Barnard	1
M. Maclean	82		C. Huisman	1
A. Morton	70		C. Mateke & M. Imakando	1
M. J. Botha	64		C. Meyer	1
S. Mecenero	62		D. Muller	1
S. C. Collins	27		E. Engelking	1
Q. Grobler	25		F. Visser	1
D. Wood	14		G. Grieve	1
P. Webb	13		H. Heya	1
C. Schuster	10		H. Otto	1
G. Hoile	10		I. Thomas	1
H. Vermaak	7		J. D. Hill	1
P. English	6		J. Grosel	1
P. Vos	6		J. Kemper	1
S. Basel	6		J. Saksida	1
S. du Preez	6		K. W. & G. R. H. Grieve	1
S. E. Woodhall	5		L. Baldwin & A. Morton	1
B. Altenroxel	4		L. Bentley	1
C. Risch	4		L. le Roux	1
J. Groenewald	4		M. Henrion	1
A. Coetzer	2		M. Maclean & M. Brink	1
A. Coetzer & E. Brand	2		M. Olivier	1
A. Konda	2		M. Way	1
C. Reynolds	2		R. Taylor	1
M. Roberts	2		S. Atkins	1
R. Peckover	2			

Table 2 – A list of hymenopteran parasitoids with their lepidopteran hosts, identified to at least family level.

Hymenopteran parasitoid*				**Lepidopteran host***		
Family	**Subfamily**	**Tribe**	**Species**	**Family**	**Subfamily**	**Species**
Bethylidae				?Tortricidae		1 species NI
Braconidae				?Crambidae		1 species NI
Braconidae				?Geometridae		1 species NI
Braconidae				?Nolidae	?Nolinae	2 species NI
Braconidae				Erebidae	Erebinae	1 species NI
Braconidae				Geometridae		5 species NI
Braconidae				Geometridae	Ennominae	*Ascotis reciprocaria*
Braconidae				Geometridae	Laurentiinae	*Haplolabida inaequata*
Braconidae				Geometridae	Sterrhinae	*Palaeaspilates inoffensa*
Braconidae				Noctuidae	Noctuinae	?*Agrotis segetum*
Braconidae				Noctuidae	Noctuinae	?*Agrotis* sp.
Braconidae				Noctuidae	Noctuinae	*Agrotis segetum*
Braconidae				Noctuidae	Noctuinae	*Agrotis segetum*
Braconidae				Plutellidae	Plutellinae	*Plutella xylostella*
Braconidae				Tortricidae		1 species NI
Braconidae	Braconinae			Erebidae	Boletobiinae	*Eublemma* sp.
Braconidae	Braconinae			Geometridae	Ennominae	*Isturgia deerraria*
Braconidae	Braconinae		?*Archibracon servillei*	Saturniidae	Saturniinae	*Bunaea alcinoe*
Braconidae	Euphorinae			Erebidae	Calpinae	*Exophyla multistriata*
Braconidae	Microgastrinae			?Crambidae		2 species NI
Braconidae	Microgastrinae			?Nolidae		1 species NI
Braconidae	Microgastrinae			Erebidae	Erebinae	*Pandesma robusta*
Braconidae	Microgastrinae			Erebidae	Lymantriinae	1 species NI
Braconidae	Microgastrinae			Erebidae	Lymantriinae	*Psalis africana*
Braconidae	Microgastrinae			Geometridae		3 species NI
Braconidae	Microgastrinae			Geometridae	Ennominae	*Drepanogynis cambogiaria*
Braconidae	Microgastrinae			Noctuidae	Plusiinae	*Chrysodeixix chalcites*
Braconidae	Microgastrinae			Pieridae	Pierinae	*Pieris brassicae*
Braconidae	Microgastrinae			Tortricidae		1 species NI
Encyrtidae				Noctuidae	Plusiinae	1 species NI
Eulophidae	Entedoninae			Noctuidae	Plusiinae	1 species NI
Eurytomidae	Eurytominae			Cecidosidae		*Scyrotis sp.*
Ichneumonidae				?Nolidae	?Nolinae	1 species NI
Ichneumonidae				Erebidae	Lymantriinae	*Euproctis bicolor*
Ichneumonidae				Geometridae		4 species NI
Ichneumonidae				Geometridae	Ennominae	1 species NI
Ichneumonidae				Geometridae	Sterrhinae	*Rhodometra sacraria*
Ichneumonidae				Noctuidae		2 species NI
Ichneumonidae				Noctuidae	Heliothinae	*Heliothis scutuligera*
Ichneumonidae	Anomaloninae			?Geometridae		1 species NI
Ichneumonidae	Anomaloninae			Geometridae	Ennominae	*Isturgia catalaunaria*
Ichneumonidae	Campopleginae			Erebidae	Boletobiinae	*Eublemma cf. reducta*
Ichneumonidae	Campopleginae			Gelechiidae		1 species NI
Ichneumonidae	Campopleginae			Notodontidae	Pygaerinae	*Clostera violcearia*
Ichneumonidae	Campopleginae	Campoplegini	*Charops* sp.	?Crambidae		1 species NI
Ichneumonidae	Campopleginae	Campoplegini	*Charops* (possibly *C. spinitarsis*)	Nymphalidae	Biblidinae	*Eurytela hiarbas*
Ichneumonidae	Cremastinae			?Tineidae		1 species NI
Ichneumonidae	Metopiinae			Erebidae	Arctiinae	*Saenura flava*
Ichneumonidae	Metopiinae			Geometridae	Sterrhinae	*Rhodometra sacraria*
Ichneumonidae	Ophioninae		*Enicospilus* sp.	Lasiocampidae		1 species NI
Ichneumonidae	Tryphoninae		*Netelia* sp.	Erebidae	Erebinae	*Pandesma robusta*
Ichneumonidae / Braconidae				Noctuidae	Acontiinae	*Cardiosace perilis*
Ormyridae			*Ormyrus* sp.	Cecidosidae		*Scyrotis* sp.

* ? = Likely identification but needs further investigation; * NI = Needs identification.

Table 3 – List of identified lepidopteran hosts parasitised by dipteran parasitoids.

Family	Subfamily*	Species*
Erebidae	Anobinae	*Plecoptera arctinotata*
	Lymantriinae	*Euproctis aethiopica*
	Lymantriinae	*Euproctis bicolor*
	Lymantriinae	*Laelia municipalis*
	Scoliopteryginae	*Anomis* sp.
Geometridae	Ennominae	*Acrasia crinita*
	Ennominae	*Heterostegane rectistriga*
Lasiocampidae	Gonometinae	*Anadiasa jansei*
	Lasiocampinae	*Eutricha obscura*
Noctuidae	Heliothinae	*Helicoverpa armigera*
	Plusiinae	NI
Notodontidae	Thaumetopoeinae	*Anaphe panda*
Pieridae	Pierinae	*Pontia helice helice*
Pyralidae	NI	NI
Sphingidae	Macroglossinae	*Basiothia schenki*
	Smerinthinae	*Pseudoclanis postica*

* NI = Needs identification.

Table 4 – Number of Lepidoptera-host associations recorded per region and country in the Afrotropical region (n = 11 054).

Region	No. of records		Country	No. of records
Southern Africa	10 338		South Africa	8 378
East Africa	535		Country unrecorded	1 717
Central Africa	86		Tanzania	430
Region unrecorded	67		Namibia	105
Madagascarene	25		Eswatini	103
West Africa	2		Zimbabwe	98
Arabian Peninsula	1		Kenya	96
			Zambia	55
			Malawi	23
			Madagascar	22
			Ethiopia	6
			Mozambique	6
			Comoro Islands	2
			DRC	2
			Lesotho	2
			Rwanda	2
			Gambia	1
			Ghana	1
			Mauritius	1
			Oman	1
			Principe	1
			Sierra Leone	1
			Uganda	1

Table 5 – Number of Lepidoptera-host associations (rearings) per Lepidoptera family for southern Africa (n = 11 007).

Lepidoptera family	No. of rearings		Lepidoptera family	No. of rearings
Erebidae	1 769		Somabrachyidae	20
Geometridae	1 621		Uraniidae	15
Lycaenidae	1 063		Galacticidae	13
Noctuidae	972		Bucculatricidae	12
Nymphalidae	852		Choreutidae	12
Saturniidae	520		Anomoeotidae	9
Sphingidae	511		Drepanidae	9
Lasiocampidae	486		Elachistidae	7
Hesperiidae	339		Sesiidae	7
Pieridae	286		Hepialidae	6
Crambidae	296		Hyblaeidae	6
Notodontidae	246		Lyonetiidae	5
Tortricidae	236		Brahmaeidae	4
Pyralidae	234		Cosmopterigidae	4
Gelechiidae	160		Lacturidae	4
Gracillariidae	159		Carposinidae	3
Nolidae	149		Heliozelidae	3
Papilionidae	137		Lecithoceridae	3
Limacodidae	92		Acrolepiidae	2
Nepticulidae	89		Adelidae	2
Psychidae	83		Epipyropidae	2
Eupterotidae	76		Scythrididae	2
Euteliidae	70		Bedelliidae	1
Gelechioidea (unspecified)	57		Blastobasidae	1
Zygaenidae	45		Brachodidae	1
Oecophoridae	33		Cecidosidae	1
Yponomeutidae	33		Himantopteridae	1
Tineidae	32		Incurvariidae	1
Pterophoridae	31		Micropterigidae	1
Ethmiidae	28		Prodidactidae	1
Bombycidae	24		Stathmopodidae	1
Cossidae	24			
Metarbelidae	24			
Plutellidae	24			
Thyrididae	23		Family unrecorded	24

Table 7 – The 20 most reared Lepidoptera species (n = 930 rearings).

Lepidoptera species	Lepidoptera family	No. of rearings	Number of host species recorded	Number of host families recorded
Helicoverpa armigera	Noctuidae	175	136	39
Nudaurelia cytherea	Saturniidae	65	60	17
Chiasmia brongusaria	Geometridae	56	7	1
Achaea lienardi	Erebidae	52	46	20
Eutricha capensis	Lasiocampidae	44	32	13
Spodoptera littoralis	Noctuidae	44	38	18
Hippotion celerio	Sphingidae	42	26	7
Ascotis reciprocaria	Geometridae	41	36	24
Cabera strigata	Geometridae	41	2	1
Acherontia atropos	Sphingidae	40	31	12
Papilio demodocus	Papilionidae	37	23	5
Hypocala rostrata	Erebidae	35	16	4
Saenura flava	Erebidae	35	25	10
Rhodogastria amasis	Erebidae	34	27	16
Vanessa cardui	Nymphalidae	33	29	3
Achaea catella	Erebidae	32	19	9
Coeliades forestan	Hesperiidae	32	28	10
Deudorix antalus	Lycaenidae	32	31	9
Isturgia deerraria	Geometridae	30	15	2
Menophra jansei	Geometridae	30	26	21

Table 8 – Number of Lepidoptera-host associations per host taxon (mostly family) for southern Africa (n = 10 981).

Host taxon	No. reared	Host taxon	No. reared	Host taxon	No. reared	Host taxon	No. reared
Fabaceae	2 122	Stilbaceae	44	Onagraceae	6	Coriariaceae	1
Asteraceae	600	Olacaceae	43	Orchidaceae	6	Cycadaceae	1
Malvaceae	564	Bignoniaceae	42	Aquifoliaceae	5	Escalloniaceae	1
Anacardiaceae	476	Menispermaceae	35	Cactaceae	5	Gesneriaceae	1
Poaceae	351	Polygonaceae	35	Cupressaceae	5	Gisekiaceae	1
Celastraceae	344	Sapotaceae	35	Dipterocarpaceae	5	Grossulariaceae	1
Rubiaceae	310	Malpighiaceae	32	Platanaceae	5	Haloragaceae	1
Combretaceae	276	Ranunculaceae	32	Smilacaceae	5	Hypoxidaceae	1
Sapindaceae	223	Chrysobalanaceae	31	Caryophyllaceae	4	Kewaceae	1
Rhamnaceae	214	Araceae	30	Dioscoreaceae	4	Kirkiaceae	1
Euphorbiaceae	205	Icacinaceae	30	Hamamelidaceae	4	Linaceae	1
Proteaceae	198	Loganiaceae	29	Lythraceae	4	Magnoliaceae	1
Capparaceae	192	Zamiaceae	29	Strelitziaceae	4	Molluginaceae	1
Lamiaceae	186	Plumbaginaceae	28	Tropaeolaceae	4	Myoporaceae	1
Apocynaceae	179	Achariaceae	27	Violaceae	4	Nephrolepidaceae	1
Ebenaceae	177	Amaryllidaceae	27	Adiantaceae	3	Nyctaginaceae	1
Moraceae	170	Cyperaceae	24	Cunoniaceae	3	Nymphaeaceae	1
Acanthaceae	143	Nyctaginaceae	24	Dennstaedtiaceae	3	Osmundaceae	1
Loranthaceae	130	Primulaceae	24	Eriospermaceae	3	Phytolaccaceae	1
Solanaceae	127	Araliaceae	23	Erythroxylaceae	3	Putranjivaceae	1
Myrtaceae	125	Fagaceae	23	Gentianaceae	3	Resedaceae	1
Vitaceae	125	Melianthaceae	23	Musaceae	3	Saxifragaceae	1
Rutaceae	109	Thymelaeaceae	23	Oliniaceae	3	Taxodiaceae	1

Boraginaceae	107		Commelinaceae	22		Orobanchaceae	3		Vahliaceae	1
Rosaceae	105		Restionaceae	19		Papaveraceae	3		Plant family unspecified	218
Phyllanthaceae	100		Apiaceae	18		Pittosporaceae	3			
Cannabaceae	95		Salvadoraceae	17		Podocarpaceae	3			
Meliaceae	88		Arecaceae	16		Polygalaceae	3			
Salicaceae	87		Bruniaceae	16		Ptaeroxylaceae	3			
Passifloraceae	86		Myricaceae	16		Talinaceae	3		**Non-plant associations:**	
Pinaceae	85		Myrsinaceae	15		Velloziaceae	3		Lichens (unspecified)	58
Asparagaceae	83		Pedaliaceae	15		Cannaceae	2		Cyanobacteria	18
Brassicaceae	82		Cucurbitaceae	12		Cistaceae	2		Insecta (unspecified)	15
Zygophyllaceae	82		Lauraceae	12		Dichapetalaceae	2		Homoptera (unspecified)	11
Santalaceae	77		Stangeriaceae	12		Juncaceae	2		Coccidae	8
Annonaceae	76		Cleomaceae	11		Lecythidaceae	2		Lecanoromycetes	3
Verbenaceae	74		Oxalidaceae	11		Lophiocarpaceae	2		Apidae	2
Crassulaceae	71		Portulacaceae	11		Melastomataceae	2		Bryophyta	2
Ericaceae	64		Asphodelaceae	10		Monimiaceae	2		Diaspididae	2
Urticaceae	62		Balsaminaceae	10		Pteridaceae	2		Formicidae	2
Scrophulariaceae	61		Caprifoliaceae	10		Theaceae	2		Jassidae	2
Oleaceae	60		Limeaceae	10		Valerianaceae	2		Algae	1
Aizoaceae	59		Zingiberaceae	10		Agavaceae	1		Fungi (unspecified)	1
Amaranthaceae	55		Ulmaceae	9		Begoniaceae	1		Marchantiophyta	1
Burseraceae	51		Clusiaceae	8		Bryaceae	1		Nymphalidae	1
Geraniaceae	51		Iridaceae	8		Canellaceae	1		Tettigometridae	1
Liliaceae	51		Selaginaceae	8		Caricaceae	1			
Ochnaceae	48		Montiniaceae	7		Casuarinaceae	1			
Convolvulaceae	45		Rhizophoraceae	7		Connaraceae	1			

Table 9 – The 19 most recorded host-plant species (n = 1 478 rearings).

Host species	Host family	Rearings	Number of Lepidoptera species recorded	Number of Lepidoptera families recorded	% Lepidoptera species/rearings
Vachellia karroo	Fabaceae	356	158	22	44
Gymnosporia buxifolia	Celastraceae	144	67	10	47
Ziziphus mucronata	Rhamnaceae	115	48	13	42
Acacia mearnsii	Fabaceae	100	86	13	86
Senegalia caffra	Fabaceae	71	31	9	44
Brachystegia spiciformis	Fabaceae	59	52	10	88
Osteospermum moniliferum	Asteraceae	58	39	11	67
Searsia pyroides	Anacardiaceae	56	32	10	57
Julbernardia globiflora	Fabaceae	55	44	10	80
Grewia occidentalis	Malvaceae	54	32	13	59
Ehrharta erecta	Poaceae	52	36	2	69
Searsia chirindensis	Anacardiaceae	49	30	9	61
Diospyros lycioides	Ebenaceae	47	33	14	70
Celtis africana	Cannabaceae	46	26	15	57
Combretum apiculatum	Combretaceae	46	30	14	65
Combretum molle	Combretaceae	44	33	12	75
Sclerocarya birrea	Anacardiaceae	43	27	9	63
Protea caffra	Proteaceae	42	23	10	55
Schotia brachypetala	Fabaceae	41	26	12	63

Table 10 – Number of rearings of Lepidoptera-host associations per host plant family for southern Africa compared to species diversity, for the 19 most utilised plant families. Plant families with exceptionally low percentages (the proportion of no. of rearings and no. of host specie recorded per host species diversity) are indicated with an asterisk (n = 6 946 rearings).

Host family	No. rearings	No. host species recorded	No. Lepidoptera species recorded	No. host species in southern Africa (host species diversity)	No. rearings/ host species diversity (%)	No. host species recorded/ host species diversity (%)
Fabaceae	2 201	359	747	6 374	34.5	5.6
Malvaceae	536	116	191	1 359	39.4	8.5
Asteraceae*	512	212	247	3 286	15.6	6.5
Anacardiaceae	423	67	221	453	93.4	14.8
Poaceae*	357	76	168	2 673	13.4	2.8
Celastraceae	302	39	149	336	89.9	11.6
Rubiaceae	288	92	141	866	33.3	10.6
Loranthaceae	269	32	46	234	115.0	13.7
Combretaceae	268	31	152	277	96.8	11.1
Sapindaceae	235	47	100	306	76.8	15.3
Euphorbiaceae*	227	61	118	1 482	15.3	4.1
Rhamnaceae	195	23	94	265	73.6	8.7
Capparaceae	189	32	63	273	69.2	11.7
Proteaceae	183	50	89	543	33.7	9.2
Lamiaceae	169	77	93	715	23.6	10.8
Moraceae	167	34	58	282	59.2	12
Ebenaceae	162	31	89	149	108.7	20.8
Acanthaceae	136	63	53	692	19.7	9.1
Apocynaceae*	127	63	76	1 611	7.9	3.9

Table 13 – Presenting the exponential factor (A) for the most frequently used host families for Lepidoptera families having more than 100 rearing records, in southern Africa (n = 10 478 rearings).

Lepidoptera family	**No. of rearing records (B)**	**Top host family utilised**	**No. of rearing records for top host family (D)**	**% of rearing records for top host family (D/B*100)**	**No. of host families (E)**	**Exponential factor (A = D/(B-D) x E)**	**Lepidoptera species diversity (southern Africa)**	**Top host family species diversity (southern Africa)**
Erebidae	1 578	Fabaceae	376	24	104	**33**	1 565	6 374
Geometridae	1 340	Fabaceae	355	26	87	**31**	1 531	6 374
Lasiocampidae	475	Fabaceae	162	34	58	**30**	227	6 374
Lycaenidae	1 283	Fabaceae	316	25	66	**22**	509	6 374
Pieridae	305	Capparaceae	149	49	23	**22**	64	273
Saturniidae	514	Fabaceae	145	28	51	**20**	81	6 374
Noctuidae	859	Asteraceae	142	17	84	**17**	967	3 286
Tortricidae	207	Fabaceae	42	20	56	**14**	298	6 374
Papilionidae	163	Rutaceae	87	53	12	**14**	22	488
Nymphalidae	989	Fabaceae	183	19	56	**13**	324	6 374
Hesperiidae	392	Malvaceae	108	28	32	**12**	155	1 359
Pyralidae	215	Fabaceae	44	20	42	**11**	630	6 374
Sphingidae	491	Rubiaceae	80	16	46	**10**	111	866
Hesperiidae	392	Poaceae	93	24	32	**10**	155	2 637
Pyralidae	215	Celastraceae	41	19	42	**10**	630	336
Gelechiidae	120	Fabaceae	27	23	33	**10**	597	6 374
Crambidae	252	Fabaceae	35	14	49	**8**	526	6 374
Nolidae	149	Malvaceae	39	26	23	**8**	159	1 359
Nolidae	149	Combretaceae	33	22	23	**7**	159	277
Notodontidae	234	Fabaceae	41	18	28	**6**	225	6 374
Gracillariidae	156	Fabaceae	22	14	35	**6**	175	6 374

Table 14 – Recorded Lepidoptera-host associations per subfamily and tribe in the family Fabaceae (n = 2 187).

Subfamily	**Tribe**	**No, of rearings**		**Subfamily**	**Tribe**	**No. of rearings**
Mimosoideae		**1 099**			Genisteae	12
	Acacieae	929			Desmodieae	7
	Mimoseae	109			Robinieae	7
	Ingeae	61			Undetermined to tribe	4
Faboideae		**653**			Swartzieae	3
	Phaseoleae	147			Galegeae	2
	Crotalarieae	108			Hypocalypteae	2
	Millettieae	98			Psoraleeae	2
	Dalbergieae	64		Caesalpinioideae		**425**
	Indigofereae	49			Detarieae	234
	Trifolieae	37			Cassieae	72
	Sophoreae	33			Caesalpinieae	68
	Aeschynomeneae	24			Cercideae	51
	Podalyrieae	21		Undetermined to subfamily		**10**
	Sesbanieae	20				
	Fabeae	13				

Table 16 – Recorded Lepidoptera-host associations per species in the genus *Vachellia* (n = 522).

Species	No. of rearings		Species	No. of rearings
Vachellia karroo	356		*Vachellia xanthophloea*	3
Vachellia sieberiana	35		*Vachellia borleae*	2
Vachellia nilotica	27		*Vachellia erioloba*	2
Vachellia tortilis	27		*Vachellia hebeclada*	2
Vachellia robusta	16		*Vachellia amythethophylla*	1
Vachellia kosiensis	14		*Vachellia davyi*	1
Vachellia gerrardii	12		*Vachellia kirkii*	1
Vachellia abyssinica	8		*Vachellia natalitia*	1
Vachellia exuvialis	8		*Vachellia seyal*	1
Vachellia hockii	4		*Vachellia swazica*	1

EXPLANATION OF THE MASTER LISTS

There are 28 master lists, grouped as convenient taxon groups and split in such a way as to make each list individually downloadable but form an integral part of the main article. Citations to these master lists should be as indicated for the main article. Each master list contains a table that is made up of eight columns and each row represents information on one rearing record. For each master list, the rearing records are ordered under family, subfamily and sometimes tribe headings (in some cases we offer a superfamily instead of a family name where we were uncertain of the family placement). The records are ordered by family, subfamily, species and then rearer name. Explanation of the information contained in each column is as follows:

Ref. no. This column contains references to a unique rearing number that links the notes, photographs and reared specimens gathered during the course of the rearing. A blank field indicate that there was no reference number submitted.

Lepidoptera species. This column contains the best identification that could be made of the Lepidoptera taxon at the time of publication given the resources available. The name of the taxon specialist who identified the species (if not an author) is given in brackets. A blank cell means that we were unable to identify the taxon with some certainty.

Host species (Family). This columns contain the best identifications that could be made of the host species, on which the caterpillar was feeding, at the time of publication given the resources available. A blank cell means that we were unable to identify the plant species to that level with some certainty or that feeding by the caterpillar was not confirmed. In the majority of cases the host indicated is the host on which the life stage was collected in the wild and on which the caterpillar fed subsequently. In cases where the host was presented to the larva in captivity, this is indicated. Where relevant, the name of the determiner is given in brackets. The host family name is given at the end in brackets. The phrase "reared *ab ovum*" means that the pictured larva was reared from the egg, meaning that the entire life-history of the species (all larval instars) was recorded and documented. In most cases such larvae were reared from eggs laid by a female moth collected at a light but raised on a natural host-plant of the species (though not necessarily one occurring at the locality where the female was taken), in some cases such larvae were reared from eggs found laid on a host-plant in the wild, and in a few cases the larvae were reared on an unnatural (exotic) host-plant in captivity. Such imprecisions regarding host use are, however, also contained in records of field-collected larvae, as mature larvae sometimes feed on plants they will not take in the early instars but do switch to at a later stage, and many also naturally feed on exotic plants in the wild.

Locality. This column contains a short standardised reference to the locality where the specimen used in the rearing was collected, be it any life stage or a female from which eggs were obtained. The locality field lists, in order, the locality description, followed by the closest town, province (where relevant) and then country.

Date of collection (c), pupation (p), emergence (e). This column contains the dates as indicated, where available. Missing dates are indicated by a "?".

Rearer. This column contains the name(s) of the person(s) who conducted the rearing, who may or may not have been the person who collected the rearing material.

Final instar larva. This column contains the photographs of the caterpillar of the species reared. In most cases they depict the final-instar larva and at the time it was still feeding, but in some cases they show the larva in the pre-pupation phase (usually on the ground) and in a few cases an earlier instar, where for some reason a photograph of the final instar was unavailable.

Adult. This column contains photographs of the actual adult specimen reared from the caterpillar shown in the previous column. Photographs marked with * are not of the actual adult specimen which emerged from the imaged larva.