

Karoo BioGaps project – butterfly survey results and their interpretation

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Abstract: The Karoo BioGaps project (KGBP) data acquisition phase was executed between March 2016 and December 2018. Butterfly surveyors made 82 visits to 46 survey sites, selected statistically to represent the types of habitats found in the Karoo. 600 species records were made of 101 species and 262 DNA samples were collected. The data have been analysed to compare expected butterfly occurrence with the actual observations; identify new quarter degree grid square species records and new species records for the entire KGBP study region; assess the impact of the new data on the Red List status of selected butterfly taxa; identify the butterfly functional types found in the Karoo; determine the average species richness in the Karoo vegetation types and biomes; and assess the impact of rainfall and veld condition on species richness. Recommendations are made to improve the efficiency of data acquisition in future surveys in the Karoo.

Key words: Karoo, butterfly occurrence, functional types, vegetation types, species richness, Red List assessments.

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INTRODUCTION

In early 2016 the South African National Biodiversity Institute (SANBI) assembled a consortium of academic institutions and non-government organisations to secure funding from the National Research Foundation's (NRF) Foundational Biodiversity Information Programme (FBIP) for a three-year project entitled "BioGaps: Filling biodiversity information gaps to support development decision making in the Karoo" (hereinafter referred to as the "Karoo BioGaps Project = KGBP"). The study region for the KGBP was the shale gas exploration area in the Karoo basin, South Africa, extending across the Western, Northern and Eastern Cape provinces (Fig. 1). Twelve representative taxonomic groups of flora and fauna (taxon groups) were identified, for which a substantial body of expertise and distribution data existed in South Africa: vascular plants, vertebrates (mammals, fish, amphibians, reptiles and birds) and six arthropod groups (bees, dragonflies, grasshoppers, scorpions, butterflies and spiders).

The Lepidopterists' Society of Africa (LSA) was contracted by SANBI in March 2016 to carry out the butterfly surveys for the KGBP, and the project deliverables required by December 2018 were to:

- Survey at least 30 sites and submit records to SANBI in a prescribed format
- Provide at least 500 species records (excluding duplicates at the same site)

- Provide at least 240 DNA samples
- Conduct 10 Red List assessments
- Complete 20 species pages for the SANBI website

MATERIALS AND METHODS

Data acquisition

The LSA surveying team complied with SANBI's "Compendium of fieldwork instructions", which laid down disciplined and orderly codes of conduct for interacting with the landowners and carrying out the fieldwork. Permits for collecting biological samples were obtained from the Northern, Eastern and Western Cape provincial authorities. The LSA surveyors used the "Rapid Assessment Protocol" (Terblanche & Edge, 2011) for butterflies, adapted to suit the aims of the KGBP. The surveying, sampling and recording processes for butterflies are described below.

Selection of survey sites

- Fifty 1x1 km survey sites were selected for all taxon groups to survey – thirty "compulsory" and twenty "optional" (Fig. 1). Twenty additional sites were allocated for supplementary plant surveys.
- All sites were to be broadly representative of the Karoo landscape and contained a diversity of habitat types such as flat areas, slopes, ridge or hilltops, and (ephemeral) watercourses.
- Each butterfly surveyor was allocated several "compulsory" sites and some "optional" sites by the LSA project manager.

Planning surveys and site familiarisation

- Surveyors contacted landowner(s) and arranged which dates were most convenient to visit. On the day of the survey permission to enter the property was reaffirmed before commencement of the survey.

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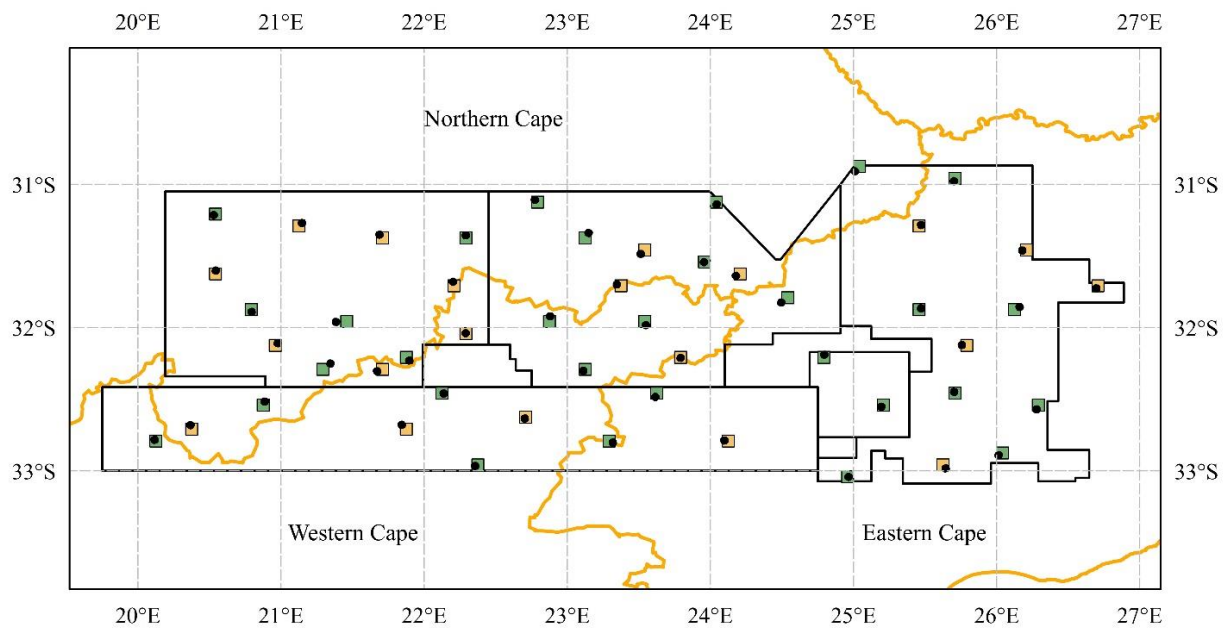


Figure 1 – Map of the KBGP study region, showing the 30 compulsory (green) and 20 optional (brown) pentads. The black dots represent the 1x1 km sites that were surveyed.

- The boundaries of the survey sites were found by GPS.
- Surveys were from 9.00 to 15.00, weather permitting.
- Areas most promising for butterflies were searched (higher ground such as hilltops and ridges around midday; north or west facing slopes; or water courses – especially in arid areas).

Data recorded

- Table 1 shows a typical datasheet with all the site metadata and survey data fields that were recorded.
- Site metadata included weather and veld condition.
- Records were made by visual observations (commoner species), photographs (showing diagnostic features), or physical specimens (rarer, difficult to identify species).
- A record included identity, time, basis of record, count, life stage, habitat, GPS coordinates, accuracy and altitude (optional) of each observation.
- Multiple sightings of the same taxon were recorded so that an overall count was made. Only one line entry was necessary, unless the sightings were a significant distance apart.
- The “specimen processing” section of Table 1 was completed at the end of the day’s surveying, after specimens had been set, DNA samples prepared and identifications made from specimens or photographs.

Preparing specimens and DNA samples

- Butterfly specimens were stunned in the field by squeezing the thorax and insertion into labelled collecting envelopes.
- There were two types of DNA samples. If the sample was being set to become a cabinet specimen several legs were removed and placed in a 2 ml sealed vial, filled to within 10mm of the brim with propylene glycol preservative. If the sample was not being set the wings were cut off close to the thorax and the thorax was placed in a similar vial. The wings were placed in a small paper envelope, also marked with the record number.

- DNA samples were stored in a freezer until they were couriered in two batches of c. 130 samples to the University of Johannesburg (UJ), with accompanying spreadsheet fully describing the samples.
- The wings of the specimens that yielded the DNA samples were photographed on both surfaces, and the images sent to UJ.

List of taxa previously recorded in KBGP study region

- Using data from the SABCA project (Mecenero *et al.*, 2013), including records published on the Virtual Museum (VM <http://vmus.adu.org.za/>) up to project commencement, a list of the taxa previously recorded in the KBGP study region was developed.
- The same SABCA and VM butterfly species records as above were allocated into calendar months, for all taxa and for priority (endemic and threatened) taxa. This helped identify which months contained the main butterfly flight periods to inform field trip planning.

New species records

The project commencement species records from SABCA and the VM as defined above had been placed into quarter degree grid squares (QDGSs). Each KBGP survey site was also allocated into a QDGS, so a comparison could be made to identify new species records for each QDGS.

Species pages and Red Listing reassessments

Species pages for 20 taxa (including information on taxonomy, descriptions, ecology, habitat, distribution and Red List status) were compiled by SANBI and reviewed by LSA experts. Ten of these taxa were selected for Red Listing; three of which were Red Listed during the Southern African Lepidoptera Conservation Assessment (SALCA) project (Mecenero *et al.*, 2015): *Crudaria wykehami*, *Aloeides clarki* and *Chrysoritis turneri wykehami*. The Red Listings of seven other taxa were also reassessed for the KBGP (*Aloeides pringlei*, *Cigaritis*

namaquus, *Iolais aphnaeoides*, *Durbania amakosa penningtoni*, *Pseudonympha trimenii nieuwwveldensis*, *Chrysoritis pan lysander* and *Lepidochrysops patricia*). New data obtained during the KBGP for these 10 taxa were uploaded into the assessment database of the SALCA tool – purpose designed software developed during the SALCA project. The Red Listings followed the IUCN guidelines (IUCN, 2017), a global standard for assessing the threat status of species.

Functional types

The butterfly taxa recorded during the KBGP were allocated to functional types as follows:

Ant associated (facultative or obligate) = AA; “Acacia” dependent (*Senegalia caffra* or *Vachellia karoo*) = AC; Aphytophagous (not feeding on plant material) = AP; Grass feeders (as larvae) = GF; Hill toppers (come to hill tops) = HT; Lichen feeders (as larvae) = LF; Migrants = MG; Mimics (of distasteful models) = MM; Mud puddlers (extract moisture from moist soil) = MP; Parasitic plant feeders (e.g. mistletoes) = PA; Poisonous plant feeders (and hence unpalatable to predators) = PO; Riverine habitats = RI; Succulent plant feeders = SU.

Biomes and vegetation types

Vegetation types (Mucina & Rutherford, 2006) (VTs) in the KBGP study region were tabulated with the biome, no. of survey sites, total km² per VT, and average species records per site, and this enabled comparisons to be made between VTs and biomes.

Rainfall and veld condition

Monthly rainfall maps for South Africa during the KBGP fieldwork were downloaded from the South African Weather Bureau (SAWB) website:

<http://www.weathersa.co.za/home/historicalrain>.

Using these maps estimates were made of the rainfall during the preceding month at each of the sites visited. Veld condition was extracted from the datasheets and tabulated with the site identity, dates visited, the rainfall estimates, and the species records obtained.

DNA sequencing and analysis

After allocating reference numbers the DNA samples were submitted via UJ to the Barcode of Life Database (BOLD) for sequencing and analysis (Ratnasingham & Hebert, 2007). The software programme FigTree version 1.4.3 was used to produce a phylogenetic tree to illustrate the relationships between the taxa sampled.

Butterfly occupancy models

The completed datasheets (Table 1) were made available to SANBI researcher Dominic Henry and the methods he used to for modelling are described in Henry (2018). The modelling aimed to determine the occupancy and detection probabilities for the butterfly community as a whole within the study region, as well as for each species observed in the study region, taking into account certain variables or covariates. These estimates were then used to determine species richness as well as species occurrence maps across the study region.

RESULTS

Site visits

82 site visits were made to 46 separate sites; all of the 30 compulsory sites, and 16 of the 20 optional sites were visited at least once (Table 2). The four sites not visited had uncooperative landowners. Five sites were visited three times, which was the most. Many of the sites were relatively flat and featureless (Fig. 2), which is not ideal habitat to obtain a high diversity of butterfly species, that tend to favour landscape features such as slopes, hillsides, ridges and hilltops. More biodiversity was encountered at sites which had variable topography (Figs 3–4).



Figure 2 – Typical featureless sampling site at Tulpleegte south of Beaufort West.



Figure 3 – Mountainous terrain at Taaiboschfontein north of Nelspoort.



Figure 4 – Variable terrain with a river valley, rocky outcrops, and a ridge at Doornberg near Nieu Bethesda.

Species previously recorded in the KBGP region

The 212 species previously recorded in the KBGP study region are detailed in Table 3, and summarised in Table 5.

Butterfly records obtained during KBGP

600 species records were obtained (defined as a species record for a site – with no duplicates) and 262 DNA samples were collected. All specimens taken or observed in the field were identified. 101 taxa were recorded (Tables 4 & 5), of which 9 taxa were new records for the KBGP study region (last column of Table 5). 43% of the taxa previously known in the KBGP study region were recorded (92 out of 212 taxa – Table 5), but very few of the localised and rare endemics were encountered. Fig. 5 on page 68 shows images of 16 taxa recorded during the KBGP.

New species records

During the KBGP species records were obtained for 21 QDGS that previously did not have a single record. Prior to the KBGP there were 383 existing species records for the QDGSs containing the 46 sites visited (Table 5). At the end of the KBGP there were 847 species records for these QDGSs – an increase of 464 or 183%. The KBGP records included 9 records of species never previously recorded in the study region (Table 5), and these are listed and annotated in Table 6.

Species pages

Species pages were prepared for the 20 selected taxa in Table 7. The species pages are now available on SANBI's Species website (<http://species.sanbi.org.za>).

Red listings

Red List assessments were re-evaluated for 10 of the taxa listed in Table 7. One was assessed as Endangered, four as Least Concern but Rare, and five as Least Concern. The Red Lists will be made accessible on SANBI's Species Status website (<http://speciesstatus.sanbi.org.za>).

Functional types

An analysis of the most prevalent butterfly functional types recorded during the KBGP is given in Table 8, with comments on the adaptive value of such life strategies in arid environments. Ant association was the predominant functional type encountered.

Vegetation types

The KBGP study region covered four biomes and 15 vegetation types (VTs – Mucina & Rutherford, 2005) over an area of c. 155000 km² (Table 9). The survey sites were unevenly representative of the VTs and the biomes, with the km² of VTs per survey site varying from 4707 (for AZi5) to 1179 (for SKv6), with higher values meaning the VT was less represented. The same applied for biomes, with e.g. Nama-Karoo (3482) being much less represented than the Succulent Karoo (1297). The yield of species records per site for different vegetation types varied from 4.0 (AZi5) to 22.0 (Gd1) (Table 9).

Rainfall and veld condition

In Table 10 the survey sites are grouped by veld condition assessments made by the surveyors and compared with the average rainfall recorded during the month before the survey at these sites and the average species records obtained per site. The latter statistic varied from 16.7 for sites in excellent condition after high rainfall to 4.9 for the worst sites which had received little rain and the veld condition was very poor. From the right hand side of Table 10 a more direct correlation between rainfall and species records obtained can also be calculated ($r^2 = 0.95$).

DNA sequencing and analysis

Table 11 shows the list of 62 species that were sampled and sent via UJ to the Barcode of life Database for sequencing and analysis.

The phylogenetic tree produced is generally consistent with current taxonomy, apart from some probably misidentified samples.

Butterfly occupancy models

Results of the modelling are detailed in Henry (2018). The detection probability after five hours of observations in was generally low, but it was highest under conditions of good veld condition, no cloud cover and higher recent rainfall, and lowest under conditions of higher wind and flat habitats. Occupancy and detection probabilities varied greatly between species. The predicted species richness was highest in the eastern, central and south-western parts of the study region.

DISCUSSION

Data acquisition

Practical problems were encountered with some of the sites selected:

- Site accessibility – sometimes the route to the 1x1 km survey site was over roads in very poor condition, even necessitating 4x4 vehicles. This could have been avoided by more thorough site reconnaissance during the planning phase of the project.
- A number of the survey sites had one or more game fences across them, which could not be climbed, and therefore time was lost in driving round to the other side of the game fence.
- The survey sites were biased towards predominantly flat areas, a habitat type that does not host many butterflies – they prefer particular landscape features such as ridges, hilltops, and water courses.
- Some 1x1 km survey sites were changed during the project. Records taken at the old sites have been included in the statistics given in the results section.

Functional types

The butterflies which occur in the Karoo have had to adapt to erratic rainfall patterns and occasional droughts, as well as periodic overgrazing by livestock during such droughts.

Some 30 percent of the larvae of butterfly species encountered rely upon ant associations (which enable in some instances aphytophagy and the absence of reliance on plant material) to survive in very arid and harsh

environments. The larvae are able to shelter in ants' nests and either practice predation on the ant brood or are fed by the ants through trophallaxis.

Grass (Poaceae) feeding is practiced by 15 percent of the butterfly species recorded during the KBGP. Poaceae species occurring in the Karoo survive droughts better than many other plant families, and rapidly respond to ephemeral rains.

Other plants exploited by butterfly larvae in the Karoo are *Senegalia caffra* Thunb. and *Vachellia karroo* (Hayne) – hardy plants that can draw water from deep sources; succulents such as Aizoaceae and Crassulaceae – that store water inside their stems and leaves into which the larvae bore; and parasitic plants such as Loranthaceae which are sometimes the only green vegetation available, and host several butterfly species.

Butterfly populations in the Karoo are normally quite small and a strategy for mate location is very important. One way of achieving this is by “hilltopping”, whereby males and females can find each other on hilltops, and some 12 percent of species encountered practice this behaviour.

The ephemeral nature of rainfall in the Karoo means that damp patches do not last long and they are exploited by “mud puddling” adult butterflies which obtain essential moisture and nutrients from these patches. Heavy rainfall, infrequent as it is, often leads to a localised butterfly population explosion and such species have strong migratory urges since the abundance of larvae will soon exhaust the supply of ephemeral plant material.

Vegetation types

From Table 9 it appears that the Grassland and Albany Thicket biomes had higher yields of species records than the Nama-Karoo and Succulent Karoo. However, this may be influenced by the lesser amount of rain received by these two biomes, which mainly lie in the western part of the study region.

Rainfall and veld condition

The rainfall recorded in the central, northern and western Karoo (<http://www.weathersa.co.za/home/historicalrain>) was way below average and this reduced the number of records obtained compared to the eastern part of the study region, which received significantly more rainfall.

Many sites were not only drought stricken, but also severely overgrazed because herbivore stock cannot be rapidly adjusted during long dry spells. These factors had a significant effect on plant diversity and hence the butterfly diversity. Only the hardier, habitat generalist or functionally adapted butterfly species can survive such conditions, and there was little chance of finding habitat specialist species, which would be endemic, endangered or rare.

Recommendations

There are still many QDGSs in the Karoo, particularly to the north of the KBGP study region, which have no records. When more normal rainfall conditions return

these areas need to be sampled over the next few years or in the next Biogaps project.

ACKNOWLEDGEMENTS

The KBGP was only made possible by the efforts of the SANBI project team, ably led by Domitilla Raimondo and Carol Poole. Other vital members of the team we often interacted with were Gigi Laidler (who arranged all the contacts with the farmers); Dewidine van der Colff who provided much technical assistance; Dominic Henry who made our efforts at detailed data acquisition worthwhile; and last but not least SANBI's statistical consultants Res Altwegg and Simon Todd who tackled the difficult challenges of site selection.

LSA's performance on this project relied on our expert team of surveyors (Table 2), who were able to rapidly locate nearly all the species at a site on a given day, often under arduous environmental conditions. Special mention should also be made of Mark Williams, who made sure that the taxonomy was correct, and André and Bennie Coetzer whose distributional database expertise was often put to good use. Another source of distributional data was the LepiMap citizen science platform (a virtual museum run by the Animal Demography Unit of the University of Cape Town) for receiving photographic records, with identifications mostly done by Fanie Rautenbach. The individuals who provided images for the Plate on page 68 are also thanked.

The University of Johannesburg is thanked for handling and forwarding our DNA samples to BOLD.

The other taxon groups provided valuable information about some of the sites, with Krystal Tolley and Corrie Basset deserving special mention.

Last, but certainly not least, to thank are the landowners of the 46 sites visited by the LSA team. They not only allowed access to the survey sites, and accommodation in several instances, but also displayed much friendliness, warmth and assistance with locating the sites.

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Table 1 – Field records: site metadata, survey data and specimen processing for the KBGP, populated with typical data.

| SITE METADATA | | | | | | Weather conditions | | | Veld condition |
|---------------|-------|-----|----------|---------|-----------|--------------------|-------|---------------|-----------------|
| Year | Month | Day | Province | Farm | Pentad | Sky | Temp. | Wind | |
| EXAMPLE | | | | | | | | | |
| 2016 | 09 | 21 | W. Cape | Kalkdam | 3245_2315 | Sunny, clear | Hot | Slight breeze | Flowers present |

| SURVEY DATA (OBSERVATIONS) | | | | | | | Decimal degrees | | | |
|--|-------|-------|----------|-------|------------|-------------|-----------------|-----------|---------|--------------|
| Record # | Time | Type* | Surveyor | Count | Life stage | Habitat | Latitude | Longitude | +/- (m) | Altitude (m) |
| EXAMPLES | | | | | | | | | | |
| DE001 | 10.10 | S | D A Edge | 2 | Adult | Watercourse | 32.80437 | 23.31365 | 5 | 350 |
| DE002 | 10.30 | V | D A Edge | 5 | Adult | Ridge slope | 32.80256 | 23.26827 | 5 | 375 |
| DE003 | 10.45 | P | D A Edge | 1 | Adult | Ridge crest | 32.80145 | 23.24562 | 5 | 390 |
| * Record types: S = specimen; V = visible ID; P = photograph | | | | | | | | | | |

SPECIMEN PROCESSING

| DNA # | Collection # | Identified by | Family | Genus | Species | Subspecies |
|----------|--------------|---------------|--------------|---------------------|-------------------|------------------|
| EXAMPLES | | | | | | |
| DE001 | 8567 | D A Edge | Lycaenidae | <i>Chrysoritis</i> | <i>pan</i> | <i>lysander</i> |
| DE002 | | D A Edge | Nymphalidae | <i>Stygionympha</i> | <i>robertsoni</i> | |
| DE003 | | D A Edge | Papilionidae | <i>Papilio</i> | <i>demodocus</i> | <i>demodocus</i> |

Table 2 – Summary of the surveyors, number of site visits made and species records obtained.

| Surveyor | No. of site visits made | | Species records | Surveyor | No. of site visits made | | Species records |
|---------------|-------------------------|----------|-----------------|---------------|-------------------------|-----------|-----------------|
| | Compulsory | Optional | | | Compulsory | Optional | |
| J.B. Ball | | 1 | 3 | A.S. Morton | 2 | | 12 |
| J.C.H. Dobson | 3 | 1 | 51 | E.L. Pringle | 6 | 3 | 123 |
| D.A. Edge | 23 | 17 | 258 | H. Selb | 3 | 2 | 17 |
| R. Jones | 2 | 1 | 14 | P.F. Ward | 12 | 2 | 97 |
| S. Kirkman | 3 | | 18 | TOTALS | 55 | 27 | 600 |
| A. Kok | 1 | | 7 | | | | |

Table 3 – Butterfly taxa recorded in the entire BioGaps study region (n = 212) prior to project commencement, extracted from the SABCA database, and supplemented by records from the Virtual Museum (denoted ^V). Endemic or near-endemic taxa in the study region are marked with an asterisk (*; n = 19). Other taxa of special concern (not endemic or near-endemic) are marked with a † (n = 9).

| | | |
|---|---|------------------------------|
| HESPERIIDAE (28 taxa) | <i>Kedestes macomo</i> | <i>Spialia nanus</i> |
| <i>Afrogegenes letterstedti</i> | <i>Kedestes niveostriga niveostriga</i> | <i>Spialia paula</i> |
| <i>Alenia sandaster</i> | <i>Kobelana kobela</i> | <i>Spialia satsaspes</i> |
| <i>Apallaga mokeezi</i> ^V | <i>Metisella malgacha malgacha</i> | <i>Spialia spio</i> |
| <i>Astictopterus inornatus</i> ^V | <i>Metisella metis paris</i> | <i>Tsitana uitehaga</i> |
| <i>Coeliades forestan forestan</i> | † <i>Metisella syrinx</i> | LYCAENIDAE (109 taxa) |
| <i>Eretis umbra umbra</i> | <i>Pelopidas thrax</i> | <i>Actizera lucida</i> |
| <i>Gomalia elma elma</i> | <i>Sarangesa phidyle</i> | <i>Actizera stellata</i> |
| * <i>Kedestes barberae bonsa</i> | <i>Spialia agylla agylla</i> | <i>Aloeides apicalis</i> |
| <i>Kedestes chaka</i> ^V | <i>Spialia asterodia</i> | <i>Aloeides aranda</i> |
| <i>Kedestes lenis alba</i> | <i>Spialia ferax</i> | <i>Aloeides arida</i> |
| <i>Kedestes lepenula</i> | <i>Spialia mafa mafa</i> | † <i>Aloeides caledoni</i> |

| | | |
|--|---|---|
| <i>Aloeides damarensis damarensis</i> | <i>Cupidopsis jobates jobates</i> | <i>*Trimenia wykehami</i> |
| <i>Aloeides depicta</i> | <i>Deudorix antalus</i> | <i>Tuxentius melaena melaena</i> |
| <i>*Aloeides dicksoni</i> | <i>Durbania amakosa penningtoni</i> | <i>Tylopaedia sardonix sardonix</i> |
| <i>Aloeides gowani</i> | † <i>Durbaniella clarki belladonna</i> | <i>Zintha hintza hintza</i> |
| <i>Aloeides juana</i> | <i>Durbaniella clarki clarki</i> | <i>Zizeeria knysna knysna</i> |
| <i>*Aloeides kaplani</i> | <i>Eicochrysops messapus messapus</i> | <i>Zizina otis antanossa</i> |
| <i>Aloeides macmasteri</i> | <i>Harpencyreus notoba</i> | <i>Zizula hylax</i> |
| <i>Aloeides oreas</i> | <i>Harpencyreus tsomo</i> | NYMPHALIDAE (52 taxa) |
| <i>Aloeides pallida pallida</i> | <i>Iolaus aphnaeoides</i> | <i>Acraea horta</i> |
| <i>Aloeides pierus</i> | <i>Iolaus mimosae mimosae</i> | <i>Aeropetes tulbaghia</i> |
| <i>*Aloeides pringlei</i> | <i>Iolaus sidus</i> | <i>Antanartia schaeneia schaeneia</i> |
| <i>Aloeides thyra thyra</i> | <i>Iolaus silas</i> | <i>Bicyclus safitza safitza</i> |
| <i>Aloeides trimeni trimeni</i> | <i>Lachnocnema durbani</i> | <i>*Cassionympha camdeboo</i> |
| <i>Aloeides vansoni</i> | <i>Lampides boeticus</i> | <i>Cassionympha cassius</i> |
| <i>Anthene amarah amarah</i> | <i>Lepidochrysops asteris</i> | <i>Catacroptera cloanthe cloanthe</i> |
| <i>Anthene definita definita</i> | † <i>Lepidochrysops bacchus</i> | <i>Charaxes jahluca jahluca</i> |
| <i>Anthene livida livida</i> | <i>Lepidochrysops grahami</i> | <i>Charaxes karkloof karkloof</i> |
| <i>Anthene millari</i> | † <i>Lepidochrysops jamesi jamesi</i> | <i>Charaxes varanes varanes^v</i> |
| <i>Anthene talboti</i> | <i>Lepidochrysops ketsi ketsi</i> | <i>Charaxes xiphares thyestes</i> |
| <i>Argyraspodes argyraspis</i> | <i>Lepidochrysops letsea</i> | <i>Danaus chrysippus orientis</i> |
| <i>Axiocerses croesus</i> | † <i>Lepidochrysops mcgregori</i> | <i>Dira clytus eurina</i> |
| <i>Azanus jesous</i> | <i>Lepidochrysops ortygia</i> | <i>Dira oxylus^v</i> |
| <i>Azanus moriqua</i> | <i>Lepidochrysops patricia</i> | <i>Eurytela hiarbas angustata</i> |
| <i>Azanus ubaldus</i> | <i>Lepidochrysops robertsoni</i> | <i>Hypolimnias misippus</i> |
| <i>Brephidium metophis</i> | <i>Lepidochrysops southeyae</i> | <i>Junonia hierta cebrene</i> |
| <i>Cacyreus dicksoni</i> | <i>Lepidochrysops variabilis</i> | <i>Junonia oenone oenone</i> |
| <i>Cacyreus fracta fracta</i> | <i>*Lepidochrysops victori</i> | <i>Junonia orithya madagascariensis</i> |
| <i>Cacyreus lingeus</i> | <i>Leptomyrina hirundo</i> | <i>Melampias huebneri huebneri</i> |
| <i>Cacyreus marshalli</i> | <i>Leptomyrina lara</i> | <i>Melanitis leda</i> |
| <i>Chilades trochylus</i> | <i>Leptotes brevidentatus</i> | <i>Neita durbani</i> |
| <i>Chrysoritis azurius</i> | <i>Leptotes pirthous pirthous</i> | <i>Paralethe dendrophilus dendrophilus</i> |
| <i>*Chrysoritis beaufortia beaufortia</i> | <i>Lycaena clarki</i> | <i>Pardopsis punctatissima</i> |
| † <i>Chrysoritis beaufortia charlesi</i> | <i>Orachrysops nasutus nasutus</i> | <i>Phalanta phalantha aethiopica</i> |
| <i>*Chrysoritis beaufortia sutherlandensis</i> | <i>Orachrysops subravus</i> | <i>Precis archesia archesia</i> |
| <i>Chrysoritis beulah</i> | <i>Oraidium barberae</i> | <i>Precis octavia sesamus</i> |
| <i>Chrysoritis braueri</i> | <i>Phasis braueri</i> | <i>Pseudonympha gaika</i> |
| <i>Chrysoritis chrysantas</i> | <i>Phasis clavum clavum</i> | <i>Pseudonympha magoides</i> |
| <i>Chrysoritis chrysaor</i> | <i>*Phasis clavum erythema</i> | <i>Pseudonympha paludis</i> |
| <i>Chrysoritis felthami dukei</i> | <i>*Phasis pringlei</i> | <i>Pseudonympha southeyi wykehami</i> |
| <i>*Chrysoritis midas</i> | <i>Stugeta bowkeri bowkeri</i> | <i>Pseudonympha trimenii namaquana</i> |
| <i>Chrysoritis pan lysander</i> | <i>Tarucus sybaris sybaris</i> | <i>Pseudonympha trimenii nieuwveldensis</i> |
| <i>Chrysoritis turneri amatola</i> | <i>Tarucus thespis</i> | <i>*Pseudonympha trimenii ruthae</i> |
| <i>Chrysoritis turneri turneri</i> | <i>*Thestor camdeboo</i> | <i>Pseudonympha varii</i> |
| † <i>Chrysoritis turneri wykehami</i> | <i>*Thestor compassbergae</i> | <i>Serradinga bowkeri bella</i> |
| <i>*Chrysoritis violescens</i> | <i>*Thestor pringlei</i> | <i>Serradinga clarki clarki</i> |
| <i>Crudaria capensis</i> | <i>Thestor protumnus aridus</i> | <i>Stygionympha irrorata</i> |
| <i>Crudaria leroma</i> | <i>Trimenia argyroplaga argyroplaga</i> | <i>Stygionympha robertsoni</i> |
| † <i>Crudaria wykehami</i> | <i>Trimenia macmasteri macmasteri</i> | <i>Stygionympha scotina scotina</i> |

| | | |
|--|---|--|
| <i>Stygionympha wichgrafi williami</i> | <i>Papilio dardanus cenea</i> ^V | <i>Colotis evagore antigone</i> |
| <i>Tarsocera dicksoni</i> | <i>Papilio demodocus demodocus</i> | <i>Colotis evenina evenina</i> |
| <i>Tarsocera fulvina</i> | <i>Papilio echerioides echerioides</i> ^V | <i>Dixeia charina charina</i> |
| <i>Tarsocera namaquensis</i> | <i>Papilio nireus lyaeus</i> | <i>Eurema brigitta brigitta</i> |
| * <i>Tarsocera southeysae</i> | PIERIDAE (19 taxa) | <i>Mylothris agathina agathina</i> |
| <i>Telchinia anacreon</i> | <i>Belenois aurota</i> | <i>Mylothris trimenia</i> ^V |
| <i>Torynesis hawequas</i> | <i>Belenois creona severina</i> | <i>Nepheronia buquetii buquetii</i> |
| * <i>Torynesis magna</i> | <i>Belenois gidica abyssinica</i> | <i>Pinacopteryx eriphia eriphia</i> |
| <i>Torynesis mintha mintha</i> | <i>Belenois zochalia zochalia</i> | <i>Pontia helice helice</i> |
| <i>Vanessa cardui</i> | <i>Catopsilia florella</i> | <i>Teracolus agoye bowkeri</i> |
| <i>Vanessa hippomene hippomene</i> | <i>Colias electo electo</i> | <i>Teracolus eris eris</i> |
| <i>Ypthima asterope hereroica</i> | <i>Colotis antevippe gavis</i> | |
| PAPILIONIDAE (4 taxa) | <i>Colotis euipe omphale</i> | |

Table 4 – Butterfly taxa recorded during the KBGP field surveys (n =101). Nine taxa were new records for the KBGP region and are preceded by +. Endemics to the KBGP study region are preceded by * (n = 2). No threatened or rare taxa were recorded.

| | | |
|---------------------------------------|---------------------------------------|---|
| HESPERIIDAE (11 taxa) | <i>Argyraspodes argyraspis</i> | <i>Phasis braueri</i> |
| <i>Afrogegenes letterstedti</i> | <i>Azanus jesous</i> | <i>Stugeta bowkeri bowkeri</i> |
| <i>Alenia sandaster</i> | <i>Azanus moriqua</i> | <i>Trimenia macmasteri macmasteri</i> |
| <i>Eretis umbra umbra</i> | <i>Azanus ubaldus</i> | <i>Tylopaedia sardonys sardonys</i> |
| <i>Gomalia elma elma</i> | <i>Brephidium metophis</i> | <i>Zizeeria knysna knysna</i> |
| <i>Kedestes macomo</i> | <i>Cacyreus dicksoni</i> | NYPHALIDAE (20 taxa, 2 new) |
| <i>Metisella malgacha malgacha</i> | <i>Cacyreus fracta fracta</i> | + <i>Acraea neobule neobule</i> |
| <i>Spialia agylla agylla</i> | <i>Cacyreus marshalli</i> | <i>Aeropetes tulbaghia</i> |
| <i>Spialia ferax</i> | <i>Chilades trochylus</i> | + <i>Byblia ilithyia</i> |
| <i>Spialia nanus</i> | <i>Chrysoritis chrysantus</i> | <i>Cassionympha cassius</i> |
| <i>Spialia spio</i> | <i>Chrysoritis chrysaor</i> | <i>Catacroptera cloanthe cloanthe</i> |
| <i>Tsitana uitenhaga</i> | <i>Chrysoritis pan lysander</i> | <i>Charaxes jahlnusa jahlnusa</i> |
| LYCAENIDAE (56 taxa, 7 new) | <i>Chrysoritis turneri wykehami</i> | <i>Danaus chrysippus orientis</i> |
| <i>Aloeides arida</i> | + <i>Cigaritis namaquus</i> | <i>Dira clytus eurina</i> |
| + <i>Aloeides braueri</i> | + <i>Cigaritis phanes</i> | <i>Hypolimnas misippus</i> |
| + <i>Aloeides clarki</i> | <i>Crudaria capensis</i> | <i>Junonia hierta cebrene</i> |
| <i>Aloeides damarensis damarensis</i> | <i>Crudaria leroma</i> | <i>Neita durbani</i> |
| <i>Aloeides depicta</i> | <i>Crudaria wykehami</i> | <i>Pseudonympha magoides</i> |
| <i>Aloeides gowani</i> | <i>Deudorix antalus</i> | <i>Pseudonympha trimenii nieuwveldensis</i> |
| <i>Aloeides macmasteri</i> | <i>Durbania amakosa penningtoni</i> | <i>Pseudonympha trimenii ruthae</i> |
| + <i>Aloeides molomo molomo</i> | <i>Eicochrysops messapus messapus</i> | <i>Stygionympha irrorata</i> |
| <i>Aloeides pallida pallida</i> | <i>Iolaus aphnaeoides</i> | <i>Stygionympha robertsoni</i> |
| <i>Aloeides pierus</i> | <i>Iolaus mimosae mimosae</i> | <i>Tarsocera fulvina</i> |
| * <i>Aloeides pringlei</i> | <i>Iolaus sidus</i> | * <i>Torynesis magna</i> |
| + <i>Aloeides sp. nova</i> | <i>Lampides boeticus</i> | <i>Vanessa cardui</i> |
| <i>Aloeides thyra thyra</i> | <i>Lepidochrysops ortygia</i> | <i>Ypthima asterope hereroica</i> |
| <i>Aloeides trimeni trimeni</i> | <i>Lepidochrysops patricia</i> | PAPILIONIDAE (1 taxon) |
| <i>Aloeides vansoni</i> | <i>Leptomyrina hirundo</i> | <i>Papilio demodocus demodocus</i> |
| <i>Anthene amarah amarah</i> | <i>Leptomyrina lara</i> | PIERIDAE (13 taxa) |
| <i>Anthene definita definita</i> | <i>Leptotes brevidentatus</i> | <i>Belenois aurota</i> |
| + <i>Anthene otacilia otacilia</i> | <i>Leptotes pirthous pirthous</i> | <i>Belenois creona severina</i> |
| <i>Anthene talboti</i> | <i>Oraidium barberae</i> | <i>Belenois gidica abyssinica</i> |

| | | |
|--------------------------------|-------------------------------------|-----------------------------|
| <i>Catopsilia florella</i> | <i>Dixeia charina charina</i> | <i>Pontia helice helice</i> |
| <i>Colias electo electo</i> | <i>Eurema brigitta brigitta</i> | <i>Teracolus eris eris</i> |
| <i>Colotis euippe omphale</i> | <i>Nepheronia buquetii buquetii</i> | |
| <i>Colotis evenina evenina</i> | <i>Pinacopteryx eriphia eriphia</i> | |

Table 5 – Summary of butterfly species records for the 50 KGBP survey sites before the project commenced and obtained during the project (surveys conducted at 46 sites). An indication is given of how many of these taxa are endemic to the KGBP study region and how many are threatened or rare. “New records” refer to taxa that had not previously been recorded in the survey sites.

| Family | Before project commenced | | | | Obtained during the KGBP | | | | |
|---------------|--------------------------|-----------|--------------------|------------------------|--------------------------|----------|--------------------|------------------------|-------------|
| | Total Taxa | Endemics | Threatened or Rare | No. of species records | Total Taxa | Endemics | Threatened or Rare | No. of species records | New records |
| Hesperiidae | 18 | | | 30 | 11 | | | 30 | 0 |
| Lycaenidae | 82 | 9 | 6 | 212 | 56 | 2 | 5 | 292 | 7 |
| Nymphalidae | 42 | 3 | | 94 | 20 | | | 151 | 2 |
| Papilionidae | 5 | | | 6 | 1 | | | 22 | 0 |
| Pieridae | 15 | | | 41 | 13 | | | 105 | 0 |
| TOTALS | 162 | 12 | 6 | 383 | 101 | 2 | 5 | 600 | 9 |

Table 6 – New butterfly species records for KGBP study region obtained during the project.

| Butterfly species | Pentad | Surveyor | Comments on the records | Specimen number |
|---------------------------|------------|-----------|--|-----------------|
| <i>Aloeides braueri</i> | 3140_2320 | P.F. Ward | Considerably out of range – poor specimen (needs confirmation) | PW125 |
| <i>Aloeides clarki</i> | 3145_2430 | D.A. Edge | Many inland records of <i>A. clarki</i> – maybe a species complex | DE168 |
| <i>Aloeides m. molomo</i> | 3105_2245 | P.F. Ward | Considerably out of range – possibly <i>Aloeides d. damarensis</i> | |
| <i>Aloeides</i> sp. nova | 3115_2525 | D.A. Edge | Specimen needed to confirm this is a new taxon | |
| <i>Anthene otacilia</i> | 3150_2525 | D.A. Edge | Very similar to <i>Anthene talboti</i> – specimen obtained | DE111 |
| <i>Cigaritis namaquus</i> | 3105_2245 | P.F. Ward | Previously only recorded in Namaqualand – no specimen | |
| <i>Cigaritis phanes</i> | 3105_2245 | P.F. Ward | Southerly extension of its range – no specimen | |
| <i>Acraea n. neobule</i> | 17 pentads | D.A. Edge | Previously overlooked and identified as <i>Acraea horta</i> | |
| <i>Byblia ilithyia</i> | 3115_2525 | D.A. Edge | Considerably out of range – but specimen obtained | DE133 |

Table 7 – The 20 butterfly taxa for which species pages were compiled. Re-assessed Red Listings were done for the ten asterisked taxa, (three were already re-assessed during the SALCA project. An indication is given as to whether or not they are habitat specialists and/or endemic to South Africa (SA). Reasons for selection of these taxa for Red Listing re-assessments and species pages are given.

| Butterfly taxon | Red Listing | Habitat specialist | Endemic to SA | Reason for selection |
|---|-----------------|--------------------|---------------|--|
| * <i>Aloeides clarki</i> | EN | Yes | Yes | SALCA taxon. |
| * <i>Aloeides pringlei</i> | LC Rare(HS) | Yes | Yes | Endemic to Karoo. |
| * <i>Chrysothrix pan lysander</i> | LC | No | Yes | Widespread typical Karoo taxon that inhabits dry rocky gullies. |
| * <i>Chrysothrix turneri wykehami</i> | LC Rare(HS, LD) | No | Yes | SALCA taxon. |
| * <i>Cigaritis namaquus</i> | LC | No | No | Thought to be a South African endemic but also occurs in Namibia. |
| * <i>Crudaria wykehami</i> | LC | No | Yes | SALCA taxon. |
| * <i>Durbania amakosa penningtoni</i> | LC Rare(HS) | Yes | Yes | Endemic to South Africa. |
| * <i>Iolaus aphnaeoides</i> | LC Rare(HS) | Yes | Yes | Endemic to South Africa. |
| * <i>Lepidochrysops patricia</i> | LC | Yes | No | Variant found in the eastern Karoo may be a new subspecies |
| * <i>Pseudonympha trimenii nieuwveldensis</i> | LC | Yes | Yes | Restricted range habitat specialist endemic found in high altitude grasslands. |
| <i>Aloeides gowani</i> | n/a | Yes | Yes | Fairly rare widespread endemic probably a habitat specialist. |
| <i>Aloeides pallida pallida</i> | n/a | No | Yes | Populations show much variability – maybe more taxa present. |
| <i>Anthene talboti</i> | n/a | Yes | No | Rarest of the Karoo's <i>Anthene</i> species – habitat specialist. |
| <i>Charaxes jahluca jahluca</i> | n/a | Yes | Yes | Only <i>Charaxes</i> found in Karoo – habitat specialist (hilltops). |
| <i>Iolaus mimosae mimosae</i> | n/a | Yes | Yes | Widespread uncommon habitat specialist (parasitic host plants). |
| <i>Lepidochrysops ortygia</i> | n/a | No | Yes | Widespread variable species – may contain cryptic taxa. |
| <i>Metisella malgacha malgacha</i> | n/a | Yes | Yes | Habitat specialist, found in moist places at high altitudes. |
| <i>Nepheronia buquetii buquetii</i> | n/a | No | No | A rarer migrant pierid that crosses the Karoo later in the summer. |
| <i>Teracolus eris eris</i> | n/a | No | No | Typical but less common Karoo pierid – migratory tendencies. |

| | | | | |
|--------------------------|-----|-----|-----|---|
| <i>Tsitana uitenhaga</i> | n/a | Yes | Yes | Habitat specialist – host plants <i>Muerxmelleri</i> sp. occur at high altitudes. |
|--------------------------|-----|-----|-----|---|

Table 8 – Analysis and interpretation of prevalent butterfly functional types (>3 occurrences) recorded during the KBGP.

| Functional types | No. | Adaptive value for arid environments |
|-----------------------|-----|--|
| Ant association | 25 | Larvae can shelter in ants nests during the day. Adults can delay emergence in drought conditions. |
| Grass feeders | 15 | Mainly some skippers and most browns (satyrines). Always some grass present even when dry. |
| Hill toppers | 12 | Good strategy for mate location when adults are scarce. |
| Mud puddlers | 10 | Can obtain moisture from any damp patches to avoid dehydration. |
| “Acacia” feeders | 8 | Very hardy trees able to survive droughts. Adult butterflies feed on flowers and larvae on leaves. |
| Migrants | 7 | Able to take advantage of ephemeral rains, breed rapidly and fly long distances to find more rain. |
| Succulent feeders | 7 | Larvae bore into succulent leaves and stems and be protected against aridity. |
| Aphytophagous | 5 | During dry conditions no host plant needed. Fed in ants nests on ant brood or by trophallaxis with ants. |
| Parasitic host plants | 4 | These plants provide the only green vegetation during droughts. |

Table 9 – Summary of vegetation types (VTs = Mucina & Rutherford, 2006), biomes, number of sites surveyed and species records obtained during the KBGP. The km² in the KBGP study region was calculated for each VT and biome. The relative sampling density and yield of species records per site are calculated for each VT and biome.

| Vegetation type (VT) | Biome | VT Code* | No. of sites | Vegetation types | | Biomes | | No. of species records | Average no. of species records per site | |
|--------------------------------|-----------------|----------|--------------|------------------|--------------------------------|-----------------|--------------------------------|------------------------|---|----------|
| | | | | km ² | Average km ² / site | km ² | Average km ² / site | | (VTs) | (biomes) |
| Eastern Upper Karoo | Nama-Karoo | NKu4 | 12 | 45989 | 3832 | 100979 | 3482 | 190 | 15.8 | 13.0 |
| Gamka Karoo | Nama-Karoo | NK11 | 7 | 20325 | 2903 | | | 80 | 11.4 | |
| Western Upper Karoo | Nama-Karoo | NKu1 | 6 | 14700 | 2450 | | | 42 | 7.0 | |
| Upper Karoo Hardeveld | Nama-Karoo | NKu2 | 3 | 11734 | 3911 | | | 53 | 17.7 | |
| Eastern Lower Karoo | Nama-Karoo | NK12 | 1 | 8321 | 8321 | | | 11 | 11.0 | |
| Karoo Escarpment Grassland | Grassland | Gh1 | 3 | 6283 | 2094 | 14874 | 2479 | 47 | 15.7 | 17.7 |
| Tarkastad Montane Shrubland | Grassland | Gs17 | 1 | 2120 | 2120 | | | 18 | 18.0 | |
| Amathole Montane Grassland | Grassland | Gd1 | 1 | 4420 | 4420 | | | 23 | 23.0 | |
| Bedford Dry Grassland | Grassland | Gs18 | 1 | 2051 | 2051 | | | 19 | 19.0 | |
| Great Fish Thicket | Albany Thicket | AT11 | 3 | 6736 | 2245 | 12467 | 2078 | 43 | 14.3 | 14.3 |
| Camdeboo Escarpment Thicket | Albany Thicket | AT14 | 1 | 1976 | 1976 | | | 19 | 19.0 | |
| Groot Thicket | Albany Thicket | AT3 | 1 | 2484 | 2484 | | | 12 | 12.0 | |
| Sundays Noorsveld | Albany Thicket | AT5 | 1 | 1271 | 1271 | | | 12 | 12.0 | |
| Roggeveld Karoo | Succulent Karoo | SKt3 | 2 | 2828 | 1414 | 5186 | 1297 | 16 | 8.0 | 6.8 |
| Koedoesberge-Moordenaars Karoo | Succulent Karoo | SKv6 | 2 | 2358 | 1179 | | | 11 | 5.5 | |
| Bushmanland Vloere | Azonal | AZi5 | 1 | 4707 | 4707 | 4707 | 4707 | 4 | 4.0 | 4.0 |
| TOTAL (or AVERAGE*) | | | 46 | 155169 | 3373* | | | 600 | 13.0* | |

Table 10 – The number of sites in each veld condition category, average rainfall during previous month and average species records obtained per site during the KBGP. The table section on the right gives the number of sites for each rainfall range, rainfall average per site and the species records obtained per site.

| Veld condition | No. of sites | Average rainfall (mm) | Species records/site | Previous month rainfall range | No. of sites | Average rainfall (mm) | Species records/site |
|-----------------------------------|--------------|-----------------------|----------------------|-------------------------------|--------------|-----------------------|----------------------|
| Excellent, green, lots of flowers | 12 | 71.7 | 16.7 | 75–140 mm | 7 | 102.1 | 16.0 |
| Good, lots of flowers | 3 | 50.0 | 12.3 | 50–74 mm | 7 | 59.3 | 12.3 |
| Fairly good, flowers | 11 | 26.6 | 10.2 | 30–49 mm | 18 | 35.6 | 10.4 |
| Fair, some flowers | 16 | 21.9 | 8.8 | 10–29 mm | 24 | 17.1 | 6.9 |
| Poor but a few flowers | 7 | 14.9 | 5.6 | 0–9 mm | 26 | 5.4 | 5.4 |
| Grassy but dry | 4 | 27.3 | 5.3 | | | | |
| Poor – dry and dusty | 29 | 15.7 | 4.9 | | | | |
| TOTAL (or AVERAGE/ SITE*) | 82 | 28.3* | 8.4* | | 82 | 28.3* | 8.4* |

Table 11 – The number of DNA samples per taxon (alphabetically listed) submitted via UJ to the Barcode of Life Database.

| Species | No. | Species | No. | Species | No. |
|-------------------------------|-----|----------------------------|-----|--------------------------------|-----|
| <i>Acræa n. neobule</i> | 6 | <i>Aloeides macmasteri</i> | 8 | <i>Anthene o. otacilia</i> | 1 |
| <i>Alenia sandaster</i> | 1 | <i>Aloeides pierus</i> | 16 | <i>Anthene talboti</i> | 2 |
| <i>Aloeides arida</i> | 1 | <i>Aloeides pringlei</i> | 1 | <i>Argyrasposes argyraspis</i> | 12 |
| <i>Aloeides braueri</i> | 1 | <i>Aloeides t. thyra</i> | 1 | <i>Azanas j. jesous</i> | 8 |
| <i>Aloeides clarki</i> | 1 | <i>Aloeides t. trimeni</i> | 1 | <i>Azanas ubaldus</i> | 12 |
| <i>Aloeides d. damarensis</i> | 13 | <i>Aloeides vansoni</i> | 9 | <i>Belenois aurota</i> | 1 |
| <i>Aloeides depicta</i> | 2 | <i>Anthene a. amarah</i> | 3 | <i>Brephidium metophis</i> | 13 |
| | | <i>Anthene d. definita</i> | 1 | <i>Byblia ilythia</i> | 1 |

| | | | | | |
|-------------------------------------|---|---------------------------------|----|-----------------------------------|------------|
| <i>Cacyreus dicksoni</i> | 1 | <i>Eicochrysops m. messapus</i> | 1 | <i>Spialia a. agylla</i> | 6 |
| <i>Cacyreus f. fracta</i> | 1 | <i>Eurema b. brigitta</i> | 3 | <i>Spialia ferax</i> | 2 |
| <i>Cacyreus marshalli</i> | 2 | <i>Iolaus m. mimosae</i> | 1 | <i>Spialia nanus</i> | 7 |
| <i>Catopsilia florella</i> | 3 | <i>Lampides boeticus</i> | 3 | <i>Stugeta b. bowkeri</i> | 1 |
| <i>Chilades trochylus</i> | 4 | <i>Lepidochrysops ortygia</i> | 1 | <i>Stygionympha irrorata</i> | 4 |
| <i>Chrysoritis chrysantas</i> | 6 | <i>Leptomyrina lara</i> | 13 | <i>Stygionympha robertsoni</i> | 9 |
| <i>Chrysoritis chrysaor</i> | 8 | <i>Leptotes p. pirithous</i> | 8 | <i>Tarsocera fulvina</i> | 1 |
| <i>Chrysoritis pan lysander</i> | 4 | <i>Metisella m. malgacha</i> | 1 | <i>Tarsocera magna</i> | 4 |
| <i>Chrysoritis turneri wykehami</i> | 1 | <i>Neita durbani</i> | 1 | <i>Trimenia m. macmasteri</i> | 2 |
| <i>Colias e. electo</i> | 1 | <i>Papilio d. demodocus</i> | 2 | <i>Tylopaedia s. sardonix</i> | 7 |
| <i>Colotis eippe omphale</i> | 5 | <i>Phasis braueri</i> | 1 | <i>Ypthima asterope hereroica</i> | 5 |
| <i>Colotis e. evenina</i> | 1 | <i>Pontia h. helice</i> | 9 | <i>Zizeeria k. knysna</i> | 4 |
| <i>Crudaria leroma</i> | 4 | <i>Pseudonympha trimenii</i> | 1 | TOTAL | 262 |
| <i>Crudaria wykehami</i> | 5 | <i>nieuwveldensis</i> | | | |
| <i>Danaus chrysippus orientis</i> | 2 | <i>Pseudonympha t. ruthae</i> | 1 | | |

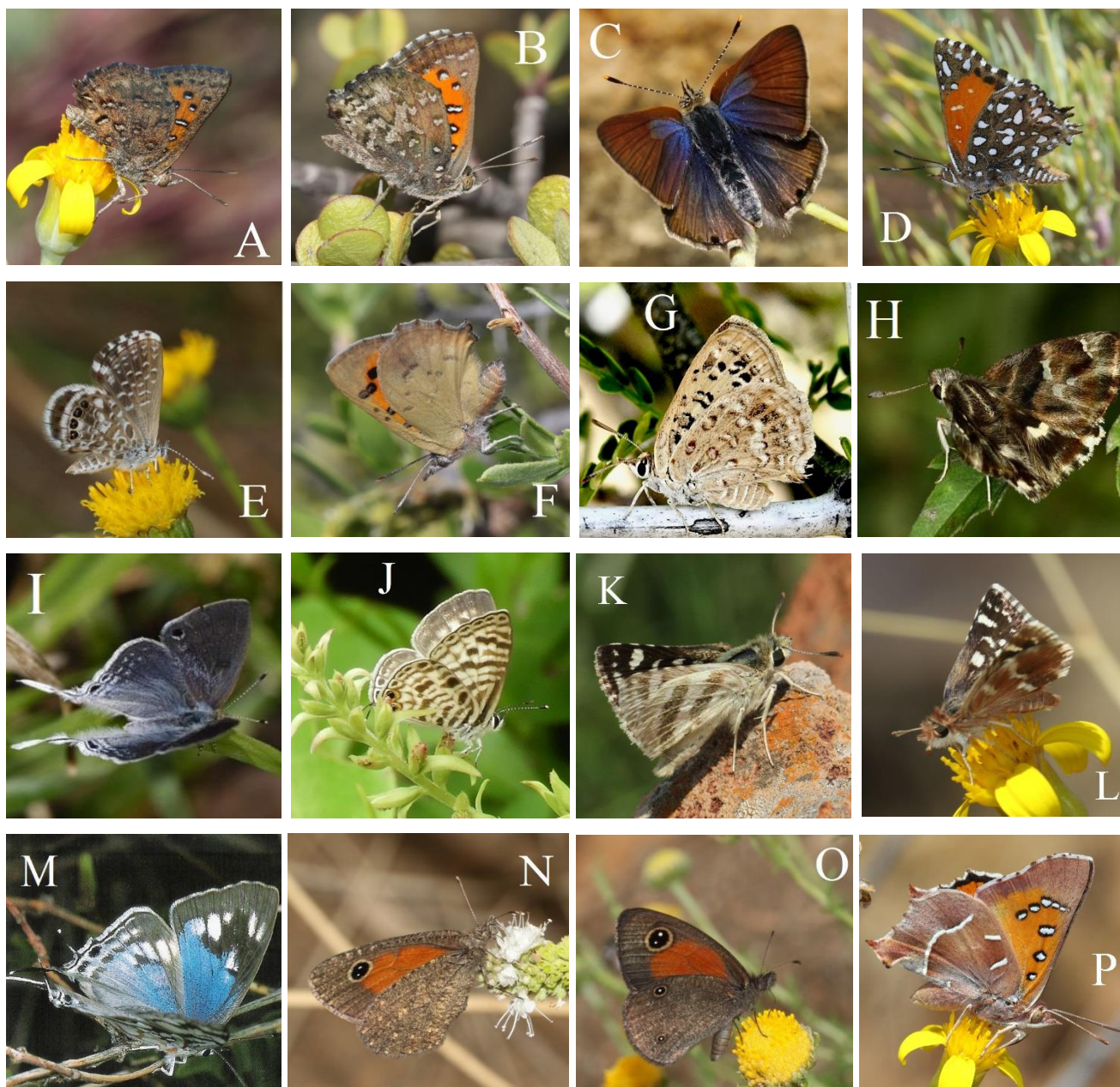


Figure 5 – Selected images of butterfly species recorded during the KBGP:

A *Aloeides d. damarensis* J. Dobson; B *Aloeides juana* J. Dobson; C *Anthene talboti* A. Sharp; D *Argyraspodes argyraspis* J. Dobson; E *Brepheidium metophis* J. Dobson; F *Chrysoritis chrysaor* J. Dobson; G *Crudaria wykehami* A. Heath; H *Gomalia elma elma* R. Schutte; I *Leptomyrina hirundo* S. Woodhall; J *Leptotes p. pirithous* H. Edge; K *Spialia ferax* J. Dobson; L *Spialia nanus* J. Dobson; M *Stugeta b. bowkeri* S. Woodhall; N *Stygionympha irrorata* J. Dobson; O *Stygionympha robertsoni* J. Dobson; P *Tylopaedia s. sardonix* J. Dobson.