Butterfly diversity and distribution in Masaya National Park, Nicaragua

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BUTTERFLY DIVERSITY AND DISTRIBUTION IN MASAYA VOLCANO NATIONAL PARK, NICARAGUA.

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Summary

The butterflies of Masaya National Park, Nicaragua are described, based on five years of data. A total of 178 species have been recorded, including 13 new national records. December was the optimum sampling period for butterflies. Six high priority areas within the Park are identified on the basis of the data presented here and associated field observations.

Resumen

Este estudio de las mariposas del Parque Nacional Volcán Masaya es basado sobre cinco años de estudios. Un total de 178 especies han sido registradas, incluyendo 13 nuevos reportes para la fauna de Nicaragua. El mes de Diciembre resultó el mes óptimo para muestreo de mariposas. Se identificó seis áreas altamente prioritarias para conservación en el Parque Nacional, basado en los datos aqui presentados y los datos de campo asociados.

Introduction

Masaya National Park (MNP) was the first to be designated as a National Park in Nicaragua. It covers an area of 54 km^2 comprising different-aged lava flows, resulting in a wide range of ecological habitats. Of particular interest are the areas of primary colonisation of open lava by vascular plants (such as on the 1772 flow) and the fragments of dry forest which have developed on much older substrates. Dry forest is considered a globally endangered habitat of which less than 2% remains of its original extent (WWF, 2001). Pacific Central American dry forests are known to exhibit a high level of endemism (Janzen, 1983). The variety of habitats found in MNP is further affected by persistent de-gassing from Santiago, the currently active crater within the volcano complex at the heart of the park. This has led to the development of a grass-dominated area to the south-west of the active crater.

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To date, there has been limited ecological work conducted in the park, although there is on-going biodiversity recording of snakes, other reptiles, birds, amphibians and bats. This manuscript is the first to present a systematic account of the diversity and distribution of one complete group of species in the park. The choice of butterflies as a group to monitor is based on five criteria. First, most species can be identified in the field or with the aid of photographs and reference sources, thereby reducing the need to take specimens. Second, assessment of the abundance and distribution can be achieved by simple sampling protocols such as walk-and-count methods (Pollard 1977, Wood and Gillman 1998). Third, butterflies are linked to particular plant species through their use either as larval host-plants (some larvae may feed on only one species of plant) and/or floral resources for adults of some species. Fourth, butterflies are sensitive to changes in conditions such as shade. The latter two reasons highlight the bio-indicator value of butterflies. Finally, butterflies are an aesthetically pleasing and charismatic component of the biodiversity of the park, with many educational opportunities.

The Neotropical region across Central and South America has the highest number of butterfly species in the world (approximately 8000 out of 19000, i.e. 47% of the total). Within Central and South America there have been a few studies of species richness and abundance of complete butterfly assemblages (e.g. Bonebrake and Sorto 2009) but none previously from Nicaragua, although a detailed list (without abundance data) from nearby Apoyo has been compiled (van Dort and McCrary 2010). Of the approximately 1250 species potentially present in Nicaragua (Warren *et al.* 2011), about 830 species are recorded (Maes 2012).

The aims of the study are as follows:

1. To determine the number and type of species of butterfly in MNP.
2. To record the abundance of species in different locations in the park.
3. To record observations of relationships between butterflies, host-plants and natural enemies in the park.
4. To use the butterfly species richness and abundance data to prioritise conservation areas in the park and to make recommendations about future study and management.
5. To undertake comparisons between Masaya National Park and other localities in Nicaragua and Central America.

Methods

This work is based on nine surveys undertaken since March 2008 covering 75 days in total, but especially on three timed walk-and-count surveys in August 2010, December 2011 and February 2012 with a total duration of 82.8 hours. The other surveys occurred in January 2011, February 2010 and 2011 and March 2008, 2009 and 2012. All surveys were conducted over a minimum of five days and led by either Gillman and/or Erenler, with Téllez Jimenez making major contributions to both the August 2010 and December 2011 surveys including providing plant and landscape knowledge. Other Park Rangers have also contributed, along with Earthwatch volunteers in the January to March sampling periods (see acknowledgements).

The basic sampling method is a timed walk-and-count based on the original method of Pollard (1977). The procedure is that two or three recorders walk a set route between 09:00 and 13:00 (earlier times are preferable in the dry season) recording all butterflies seen within approximately 5m either side and in front of the observer. Some species can be immediately identified on the wing whereas others need to be photographed *in situ* or caught in a hand net, photographed and then released. We have compiled a set of photographs which serve as our voucher specimens. Different species seen outside of the walk-and-count timed sessions are noted and included in the overall list for the park. The location of each route is recorded using a hand-held GPS device with habitat features noted concurrently. The latter are, in turn, related to remote sensed data.

The advantage of the walk-and-count method is that it is repeatable, relatively easy (depending on terrain and temperature) and does not require destructive sampling. The disadvantage is that it may lead to certain species being missed (such as high canopy feeders - some of these may be sampled with fruit traps) or underestimate the abundance of others. At Masaya the variety of height and disturbance of canopy allows us to collect data on most species.

Identification from photographs and specimens in the field was determined with three resources (Glassberg 2007, Warren et al 2011 (Butterflies of America website) and Maes 2012 Bio-Nica website), supplemented by DeVries (1987). These resources also provide information on butterfly distribution (especially Bio-Nica within Nicaragua and Butterflies of America for Central America and beyond) and larval host-plants.

Species richness estimates (Chao 1 index) and diversity statistics were generated using the EstimateS package (Colwell, 2009). A more detail statistical analysis of the species richness data, with emphasis on the different responses of butterfly families, is contained in a separate manuscript (Gillman *et al.* 2012).

Results and Discussion

Trails and general site description

Lava colonisation generally begins with lichen and fern species, with the earliest angiosperm species usually comprising small trees of *Plumeria rubra*, *Ficus* spp. and *Clusia minor*. These tend to form habitat islands with other species acting as secondary colonists both on and under them, especially epiphytic orchids and bromeliads (several species of *Tillandsia*). We have undertaken a preliminary vegetation sample across about 50 locations in the park. Primary succession is extremely slow, with the 1670s flow containing only isolated habitat islands. The older lava becomes increasingly dominated by *Bursera simaruba* with *Cochlospermum vitifolium* notable. High forest on deeper soil contains large trees such as *Ceiba pentandra*, *Bombacopsis quinata* and *Enterolobium cyclocarpum.*

Six trails radiating out from the centre of the park have each been walked a minimum of three times. To the north-west are the Las Pencas (cinder cone) and Cerro Montosa trails. The former covers open grassland, grass-scrub and low woodland (e.g. with high densities of *Byrsonima crassifolia*). The latter includes some of the highest and most mature forest in the park within an area of about one square kilometre. The Los Chokoyos trail heads south-west and then west along the edge of the caldera where it is flanked by high forest towards the grass-dominated kill zone. A few hundred metres down the Los Chokoyos trail a left turn exists that heads east and then north-east along the Jiñocuabo trail. This cuts through high forest and occasional older colonised lava fields. The Jiñocuabo trail meets the Los Coyotes trail which heads north-west towards the Visitor Centre or south-east towards Lake Masaya. The Los Coyotes trail is punctuated by high forest (mostly in the northern section), open lava, older colonised lava and open grassland. The sixth trail (Comalitos and central forest) heads along the road from the Visitor Centre and around the Comalitos cone and out onto the central open woodland/scrub (similar to Las Pencas) and then onto open lava. We have also made one excursion down into the base of the steep-sided, vegetated San Fernando crater.

Species richness and abundance

A total of 178 species have been recorded with a few species yet to be identified (represented by single individuals and recorded to family level). A full list of species is provided in the Appendix. The highest number of species was recorded during the rainy season (August 2010) and into the start of the dry season (December 2011 and February 2012), constituting 55, 71 and 52% of the total number seen (details In Table 1a). Of the 178 species, 151 were recorded during the walk and count sessions (85%). The assemblage was dominated by Hesperiidae and Nymphalidae which comprised 68% of the species (Table 1b).

Table 1. a. Number of species recorded in total and during three sampling periods (the numbers in parentheses include extra species seen outside of the walk-and-count sampling times). b. Percentage of species in different families.

a.

Family	All records	August 2010 (10 samples)	December 2011 (11 samples)	February 2012 (9 samples)
Hesperiidae	60	31	35	19
Lycaenidae	25	3	10	14
Nymphalidae	61	41	49	42
Papilionidae	7	3	4	3
Pieridae	12	8	9	10
Riodinidae	13	4	11	5
Total	178	90 (97)	118 (126)	93 (93)

b.

Family	All records	August 2010	December 2011	February 2012
Hesperiidae	34	34	30	20
Lycaenidae	14	3	8	15
Nymphalidae	34	46	42	45
Papilionidae	4	3	3	3
Pieridae	7	9	8	11
Riodinidae	7	4	9	5

The percentage of nymphalids in August, December and February periods is consistent, fluctuating between 42 and 46%, while the Hesperiidae percentage decreases and the Lycaenidae percentage increases from wet (August) to dry (February) seasons.

Abundance, expressed as encounter rate during the walk-and-count sampling, was significantly correlated with the number of sampling trips ($r = 0.817$, $n = 151$, $p < 0.001$), i.e. those with the highest number of individuals in August, December and February were seen in most seasons. Species that were seen on all trips and had an encounter rate of more than one per hour ($\log_{10}$ encounter rate > 0, Figure 1) were four species of nymphalid (*Dryas iulia*, *Hamadryas februa*, *Hamadryas glauconome* and *Siproeta stelenes*) and two species of pierid (*Eurema daira* and *Pyrisitia nise*).

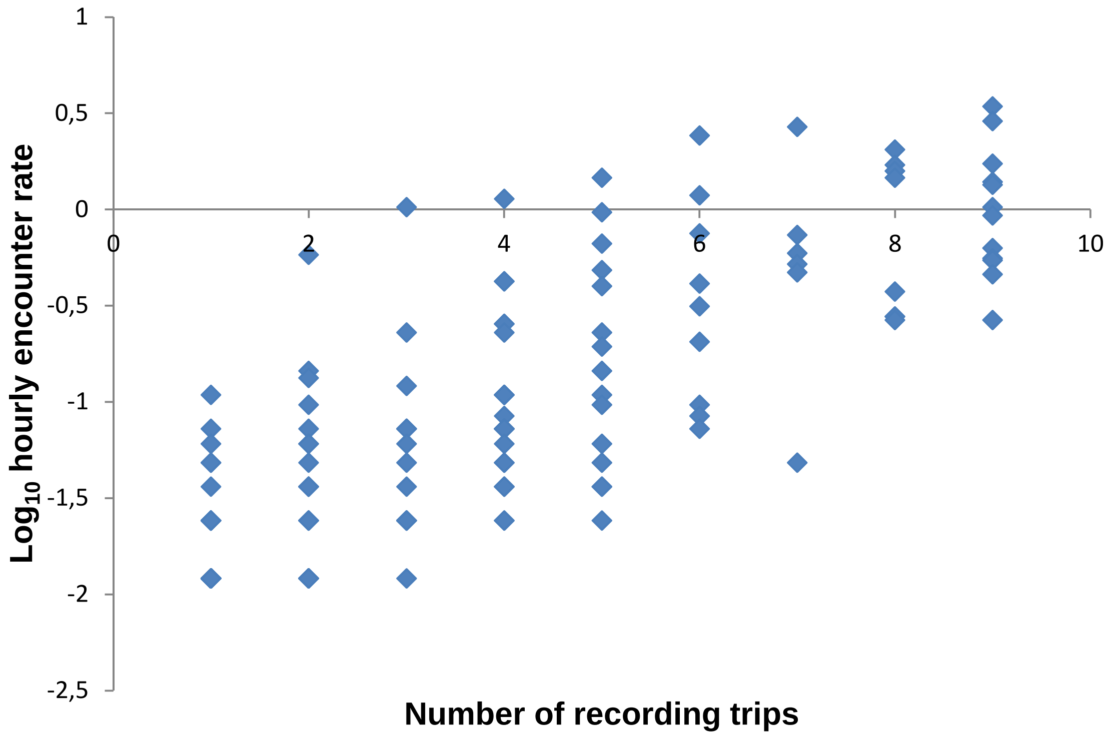

Figure 1. Relationship of encounter rate in August, December and February with number of recording trips (maximum of nine trips).

The number of butterfly species observed depends on the duration of the sampling, which can be summarised by rarefaction curves, using either the number of individuals or the number of samples (Figures 2a and 2b). After 9 samples (transects), the expected number of species in August 2010 was 87 (95% Confidence intervals 80.6 - 99.4), compared with 93 (83 – 103) in February and 109.5 (106 – 129) in December 2011, i.e. averaging 96.5 in approximately 23 hours of recording. December is seen to be significantly higher (no overlap of 95% confidence intervals) than both August and February. During high encounter days in December it is possible to see over 45 species in two to three hours, depending on the trail walked.

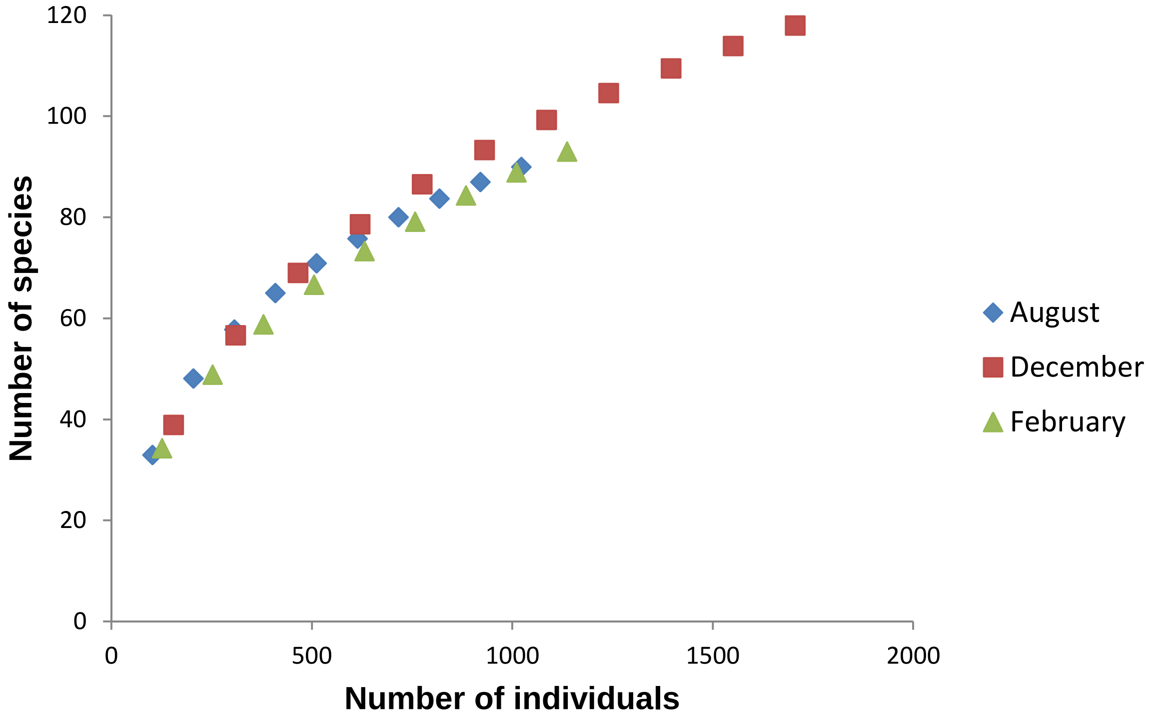

Figure 2a Increase of number of species with number of individuals for three sampling periods (Mao Tau rarefaction values).

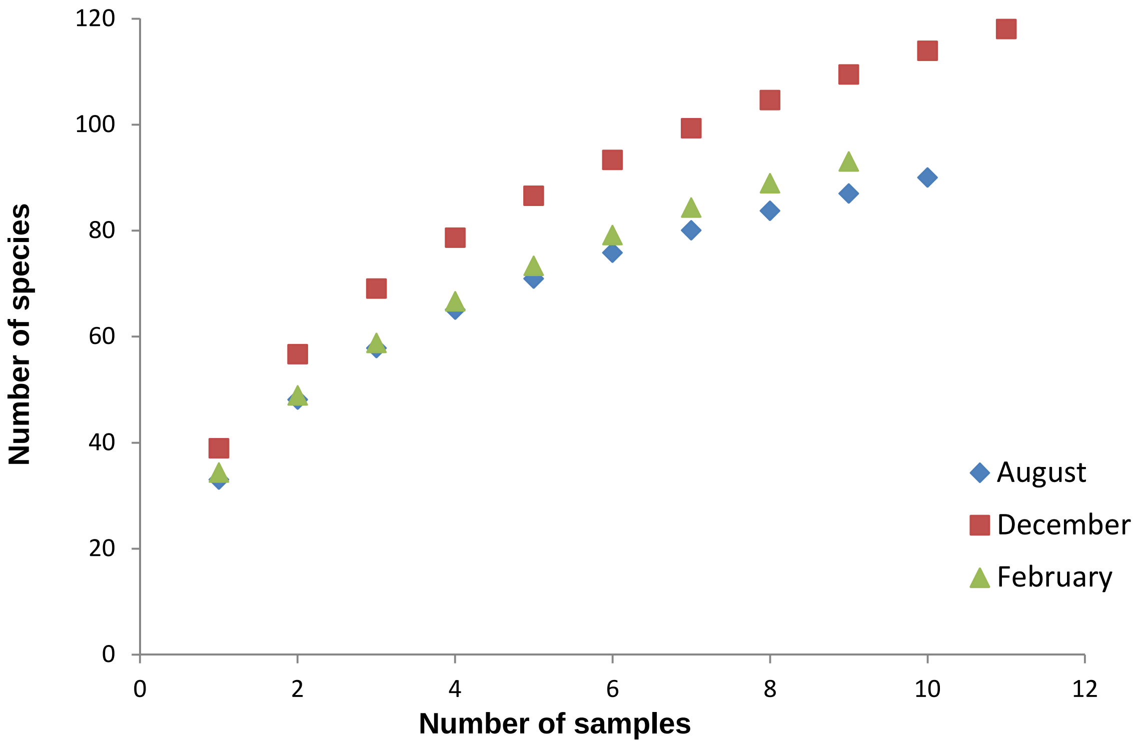

Figure 2b Increase of number of species with number of samples for three sampling periods (Mao Tau rarefaction values).

Estimated species richness from the transect data is highest for December (approximately 160) with August and February yielding very similar estimates (Table 2). Species diversity (Shannon Index) ranges from 3.6 to 3.9.

Table 2. Species richness and diversity in three separate sampling periods and overall. The observed species richness include transects and other recording periods (see Table 1). The estimated species richness is the Chao 1 index (with standard deviation) and the species diversity is the Shannon index.

	All records	Aug. 2010	Dec. 2011	Feb. 2012
Observed species richness	178	97	126	93
Estimated species richness	185.1 (14.99)	123.1 (17.2)	159.6 (18.3)	123.0 (14.8)
Species diversity	3.92	3.75	3.79	3.59
Number of samples	30	10	11	9

The Cerro Montosa, Los Coyotes and Chokoyos forested regions contain the highest number of species (98, 104 and 83 respectively). The lower species richness for the Chokoyos region is potentially due to a lower sampling effort and is expected to contain about 100 species. The Jiñocuabo trail, which is contiguous with the Los Coyotes trail, also has 80 species recorded. Clearly the species richness will change with area, connectance and disturbance but 100 species appears to be a reasonable first approximation for an area of dry forest of 1-2km^2 in this region.

The 50 most abundant species as assessed by the number seen per hour are listed (Table 3). There are no Lycaenidae in the top 50 and no Hesperiidae with an hourly encounter rate of greater than 1.

Table 3 The most abundant species (top 50) based on hourly encounter rate in samples in August 2010, December 2011 and February 2012.

Rank	Family	Species	Hourly encounter rate
1	Nymphalidae	*Siproeta stelenes*	3.43
2	Nymphalidae	*Hamadryas februa*	2.87
3	Pieridae	*Ganyra josephina*	2.68
4	Nymphalidae	*Hermeuptychia hermes*	2.42
5	Riodinidae	*Calephelis costaricicola*	2.04
6	Pieridae	*Pyrisitia nise*	1.73
7	Nymphalidae	*Magneuptychia libye*	1.70
8	Pieridae	*Phoebis sennae*	1.58
9	Nymphalidae	*Cissia themis*	1.46
10	Papilionidae	*Parides iphidamas*	1.46
11	Pieridae	*Eurema daira*	1.39
12	Nymphalidae	*Dryas iulia*	1.34
13	Pieridae	*Itaballia demophile*	1.18
14	Riodinidae	*Mesosemia telegone*	1.14
15	Nymphalidae	*Hamadryas glauconome*	1.03

16	Nymphalidae	*Chlosyne melanarge*	1.03
17	Hesperiidae	*Heliopetes macaira*	0.97
18	Nymphalidae	*Heliconius erato*	0.93
19	Nymphalidae	*Chlosyne (Thessalia) theona costaricensis*	0.75
20	Hesperiidae	*Urbanus dorantes*	0.74
21	Nymphalidae	*Taygetis virgilia*	0.66
22	Nymphalidae	*Marpesia petreus*	0.63
23	Nymphalidae	*Mestra dorcas (amymone)*	0.59
24	Nymphalidae	*Microtia elva*	0.58
25	Papilionidae	*Battus polydamus*	0.56
26	Nymphalidae	*Junonia evarete*	0.54
27	Nymphalidae	*Anthanassa frisia tulcis*	0.52
28	Pieridae	*Phoebis philea*	0.48
29	Hesperiidae	*Polygonus manueli*	0.47
30	Nymphalidae	*Heliconius charitonia*	0.46
31	Hesperiidae	*Saliana saladin*	0.42
32	Nymphalidae	*Dynamine postverta*	0.42
33	Nymphalidae	*Temenis laothoe*	0.41
34	Nymphalidae	*Taygetis laches (thamyra)*	0.40
35	Pieridae	*Pyrisitia proterpia*	0.37
36	Hesperiidae	*Pyrgus oileus*	0.31
37	Hesperiidae	*Achalarus albociliatus*	0.28
38	Nymphalidae	*Eunica monima*	0.28
39	Nymphalidae	*Myscelia ethusa*	0.27
40	Nymphalidae	*Anartia fatima*	0.27
41	Hesperiidae	*Staphylus sp*	0.25
42	Nymphalidae	*Mechanitis polymnia*	0.25
43	Nymphalidae	*Nica flavilla*	0.23
44	Nymphalidae	*Zaretis ellops*	0.23
45	Pieridae	*Eurema elathea*	0.23
46	Nymphalidae	*Smyrna blomfildia*	0.21
47	Hesperiidae	*Gorgythion begga*	0.19
48	Nymphalidae	*Dryadula phaetusa*	0.14
49	Riodinidae	*Eurybia elvina*	0.14
50	Riodinidae	*Emesis sp*	0.13

Comparing butterfly species richness at MNP with other areas

The butterfly fauna of MNP can be compared with other dry forest localities in Central America (Table 4). In El Salvador 84 species were recorded in nine days of sampling (58 collecting/netting hours) in June 2008 (Bonebrake and Sorto 2009), lying within the 95% confidence intervals of 9-day samples for the August and February Masaya walk-and-count samples but significantly less than the December samples. This comparison should be treated with caution as the number of sampling hours were different and three species in the El Salvador sample were only found in fruit traps (although two of these were detected in the walk-and-count samples at Masaya).

Luna-Reyes et al (2008) undertook 79 days of field work at 24 locations in the Cuenca del Balsas region in Mexico, recording 142 butterfly species excluding Hesperiidae. This contrasts with 118 species (excluding Hesperiidae) in Masaya over 75 days total sampling (all nine sampling sessions). Given the likelihood of encountering different species in different locations (beta diversity) for the Mexican data the Masaya total compares favourably with the Mexican data. Both of these dry forest comparisons suggest that the Masaya data are robust (also see comparisons of particular families in Gillman *et al.* 2012). The fraction of Masaya species out of the Maes list for Nicaragua is consistent across five of the families (Table 4, 0.21 – 0.29) but substantially lower for Riodinidae (0.1), perhaps because they are more localised and/or with relatively higher richness in the moist tropics. The Hesperiidae, Lycaenidae and Riodinidae account for most of the discrepancy between the Maes list and the potential numbers of species according to the Butterflies of America site. The extra 13 species included here brings the total to 845 recorded for Nicaragua so a count of 1000 species for the whole of Nicaragua seems a reasonable approximation.

Table 4 Butterfly species in different dry forest localities in Central America and the estimated total for Nicaragua (all habitat types), Values in parentheses for Masaya are the fraction of species richness in the Maes list.

	Masaya National Park (current study)	El Salvador dry forest and other coastal habitats (Bonebrake & Sorto 2009)	Mexico dry forest (Luna-Reyes *et al.* 2008)	Maes list for Nicaragua (Volume III, 2011)	Nicaragua (based on BofA.com)
Hesperiidae	60 (0.23)	22	Not recorded	262	495
Papilionidae	7 (0.26)	4	13	27	30
Pieridae	12 (0.22)	11	23	55	54
Lycaenidae	25 (0.29)	10	27	86	191
Riodinidae	13 (0.12)	6	21	109	170
Nymphalidae	61 (0.21)	31	58	293	319
Total	178 (0.21)	84		832	1259

New country records and notable species

Several of the butterflies recorded in MNP are of particular significance, either because they are restricted to certain habitats, are rare, or, because they represent new records for Nicaragua. In most cases the new country records are simply confirmations of expected occurrence based on known distribution. However, in two cases the records represent interesting supplements to a species' geographic range. The following thirteen species are new records for Nicaragua (based on absence from the Bio-Nica list, no Nicaragua specimens in Butterflies of America website and absence from the Apoyo list), and are organised into three categories depending on their geographic range. A fourteenth species, *Urbanus pronus*, would also be a new record but there is the possibility of confusion with *U. viterboana* and so it is excluded from this list until confirmed.

(i) Currently only recorded in countries north of Nicaragua

1. *Taygetis uncinata* (Mexico, Guatemala), Figure 3.

Figure 3 *Taygetis uncinata*. Jiñocuabo trail 19 Dec 2011 (Image: Erenler).

(ii) Currently only recorded in countries south of Nicaragua

2. *Calephelis sixola* (Costa Rica), Figure 4.

Figure 4 *Calephelis sixola* at Cerro montosa 17 Dec 2011. Also seen on Jiñocuabo trail and in San Fernando crater (associated with more mature forest) (Image: Erenler).

(iii) Mexico to Costa Rica (at least) and therefore expected from range but not previously recorded in Nicaragua:

3. *Behemothia godmanii* (Mexico to Costa Rica). Details below.

4. *Calephelis costaricicola* (South Mexico to Panama), Found throughout MNP in forest edge and open areas, Figure 5.

Figure 5 *Calephelis costaricicola* (Image: Erenler, 2010).

5. *Chlorostrymon simaethis* (south U.S. to Argentina). One record from Jiñocuabo trail on 16 Feb 2012 (sight record, HE).

6. *Copaeodes minima* (southern U.S. to Costa Rica). Associated with open grassland. Seen in Las Pencas area in Aug 2010 and Comalitos in Dec 2011, Figure 6.

Figure 6 *Copaeodes minima,* Las Pencas area in August 2010 (Image: Erenler, 2010).

7*. Lerodea arabus* (southern U.S. to Costa Rica), Figure 7.

Figure 7 *Lerodea arabus*, Jiñocuabo trail, December 2011 (Erenler, 2011).

8. *Monca crispinus* (southern U.S. to Colombia), Figure 8.

Figure 8 *Monca crispinus,* December 2011 Comalitos area (Image: Erenler, 2011)

9. *Oenomaus ?ortygnus* (Mexico to Brazil), Figure 9.

Figure 9 *Oenomaus ?ortygnus,* August 2010. Las Pencas scrub woodland (Image: Erenler, 2010).

10. *Strymon istapa* (southern U.S. to Argentina), Figure 10.

Figure 10 *Strymon istapa*. February 2010 near visitor car park at viewpoint. Also recorded on Chokoyes trail February 2012 (Image Erenler, 2010)

11. *Strymon ziba* (Mexico to Argentina), Figure 11.

Figure 11 *Strymon ziba* Cerro montosa December 2011 (Image: Erenler, 2011).

12. *Theritas theocritus* (Mexico to Colombia), Figure 12.

Figure 12 *Theritas theocritus.* Chokoyes trail 28 Dec 2011 (Image: Erenler, 2011)

13. *Voltinia umbra* (Mexico to Panama), Figure 13.

Figure 13 *Voltinia umbra.* August 2010 and Cerro Montosa in Dec 2011 (Images: Erenler, 2010/11).

Of the species in the third category, *Behemothia godmanii* is of particular interest as nothing is known of its life-cycle (Hall 2000) and it is only known from a few localities in Central America, including a single record in Costa Rica. The known habitat in Mexico is described as dry semi-deciduous forest from 100m – 700m which agrees with the discovery of this butterfly species in MNP along the Jiñocuabo trail (Figure 14a & 14b).

Figure 14a *Behemothia godmanii* dorsal view (Image: Erenler, 2011)

Figure 14b *Behemothia godmanii* ventral view (Image: Erenler, 2011)

Also of interest is *Oleria paula*, which was found only in the vegetated San Fernando crater (a habitat with minimal human disturbance). This species is generally only recorded at higher elevations through Nicaragua.

Recommendations : Priority areas

Based on the data presented here and the field observations made during nine visits over five years, we suggest the following six high-priority regions. These areas, representing a variety of habitats/ecosystems, are coded by letter and are illustrated in Figure 15.

1. Los Coyotes area, continuous with the Jiñocuabo trail (CO). This represents the largest area of forest (approximately 4 km^2) which has been subject to relatively low levels of disturbance.
2. Cerro Montosa high forest (CM). An area of about 1 km^2. This and the previous region (CO) are the remaining locations for the *Cebus capucinus* monkey populations in the park.
3. South-west end of the Los Chokoyos trail (CH). Area bordering the caldera wall and to the east of the kill zone.
4. San Fernando crater (SF). A small but highly inaccessible area representing an almost pristine example of different stages of primary succession from lava tubes to mature forest. It contains populations of *Oleria paula* and *Mechanitis polymnia* butterflies together with *Anthurium* sp. which has been cleared from the rest of the park, existing only as planted specimens at the park entrance.
5. Las Pencas open woodland and Cerro Sastepe to the north of Cerro Montosa (LP).
6. Remaining undisturbed areas of lava colonisation of different ages, some of which occur in the above regions.

Figure 15 Core regions/habitats of the park. The regions are roughly determined and require more detailed GIS work. The red lines represent boundaries of the two most recent lava flows and barriers to dispersal for some species. Based on Google maps image downloaded 8 January 2012

We also recommend further investigation of the forest area surrounding Lake Masaya. This area to the south is poorly known but may harbour some different species with an affinity to more humid locations.

The areas listed above are subject to a range of threats of varying severity. These include:

- **Logging**. This is mostly small-scale, but particularly prevalent in the Cerro Montosa and Jiñocuabo regions. Over the last five years this disturbance factor has increased noticeably.
- **Grazing**. The south-west section of the park and all the way up the Los Chokoyos trail is subject to heavy grazing from cattle, with associated tree removal and threat of fire. We have observed a marked increase in encounters with free-grazing cattle since 2011.
- **Removal of substrate** for roads and other building purposes. An activity that no longer appears to be taking place, this had involved the large scale removal of lava and subsequent levelling in the north and central sections of the park.

Conclusion

Masaya National Park contains a wide range of habitats from open lava to high canopy dry forest. The high species richness of butterflies highlights its ecological importance. Threats to the biodiversity of the Park come from a variety of anthropogenic sources and are exacerbated by the small, fragmented nature of the habitat. The lack of similar data from other protected areas in Nicaragua needs to be addressed.

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Appendix. Masaya National Park Butterfly check-list.

Check-list of species for Masaya National Park present (1) in different sampling sessions. Nine visits arranged in seasonal order (wet through dry). Species which are also in Apoyo list are indicated by (A) after species name, (a) indicates possibly same species. Species names and subfamily after Lamas (2009) and Wahlberg (2012) for Nymphalidae. Five unknown Hesperiidae species are indicated by a number. There are possibly a further two skipper species from August and February but the photos are poor – note there is also one potential duplication with *Urbanus pronus*/*viterboana*. Other identification uncertainties are indicated by '?'. The Pyrginae are separated into two alphabetical lists of Eudamini and Pyrgini. Family key: H = Hesperiidae, L = Lycaenidae, N = Nymphalidae, Pa = Papilionidae, Pi = Pieridae, R = Riodinidae.

Family	Subfamily	Species name	Aug 10	Dec 11	Jan 11	Feb 10	Feb 11	Feb 12	Mar 08	Mar 09	Mar 12
H	Hesperiinae	*Copaeodes minima*	1	1							
H	Hesperiinae	*Enosis sp*						1			
H	Hesperiinae	*Hylephila phyleus (a)*					1				
H	Hesperiinae	*Lerodea ?arabus*		1							
H	Hesperiinae	*Moeris striga*		1							
H	Hesperiinae	*Monca crispinus (tyrtaeus)*		1							
H	Hesperiinae	*Panoquina sylvicola*		1							
H	Hesperiinae	*Polites vibex (A)*						1			
H	Hesperiinae	*Saliana saladin (a)*	1		1			1			1
H	Hesperiinae	*Vettius fantasos*	1	1		1					1
H	poss Hesp	*Unknown 1*									1
H	Pyrginae	*Achalarus albociliatus*	1	1	1	1		1	1	1	1
H	Pyrginae	*Achalarus similar*									1
H	Pyrginae	*Aguna asander*	1								
H	Pyrginae	*Aguna metophis*	1								
H	Pyrginae	*Astraptes anaphus (A)*	1	1				1			
H	Pyrginae	*Astraptes fulgerator (A)*	1	1	1						
H	Pyrginae	*Astraptes sp.*									1
H	Pyrginae	*Cabares potrillo (A)*	1								
H	Pyrginae	*Celaenorrhinus stola*		1							
H	Pyrginae	*Chioides albofasciatus*	1								1

H	Pyrginae	*Chioides zilpa*					1				
H	Pyrginae	*Epargyreus aspina (a)*	1								
H	Pyrginae	*Epargyreus exadeus (A)*	1	1	1			1	1		1
H	Pyrginae	*Epargyreus sp.*	1								
H	Pyrginae	*Narcosius ?parisi*									1
H	Pyrginae	*Ocyba calathana*	1								
H	Pyrginae	*Polygonus manueli (A)*	1	1	1	1	1	1			1
H	Pyrginae	*Polythrix asine (A)*	1	1			1	1			1
H	Pyrginae	*Urbanus dorantes (A)*	1	1	1		1	1	1	1	1
H	Pyrginae	*Urbanus doryssus (A)*		1							
H	Pyrginae	*Urbanus esmeraldus*	1	1							
H	Pyrginae	*Urbanus pronus/viterboana*	1								
H	Pyrginae	*Urbanus simplicius (A)*		1							
H	Pyrginae	*Urbanus dorantes (A)*									
H	Pyrginae	*Urbanus teleus (and procne?) (a)*		1	1		1	1			
H	Pyrginae	*Urbanus viterboana*	1	1			1				
H	Pyrginae	*Antigonus sp*									1
H	Pyrginae	*Bolla ?giselus (a)*	1								
H	Pyrginae	*Chiomara asychis*	1	1				1			
H	Pyrginae	*Cycloglypha thrasibulus (A)*		1	1			1			
H	Pyrginae	*Clito ?aberrans*									1
H	Pyrginae	*Gorgythion begga (A)*	1	1			1	1	1		
H	Pyrginae	*Heliopetes alana (A)*		1	?						1
H	Pyrginae	*Heliopetes arsalte*	1								
H	Pyrginae	*Heliopetes laviana (A) (uncertain)*			1						
H	Pyrginae	*Heliopetes macaira*		1		1	1	1			1
H	Pyrginae	*Mylon jason/pelopidas*	1	1				1			1
H	Pyrginae	*Nisoniades sp*	1						1		
H	Pyrginae	*Unknown 2*		1							

H	Pyrginae	*Pellicia arina (A)*	1								
H	Pyrginae	*Pyrgus ?communis*	1								
H	Pyrginae	*Pyrgus oileus (A)*	1	1	1		1	1			1
H	Pyrginae	*Sostrata bifasciata (A)*		1				1			
H	Pyrginae	*Spathilepia clonius (A)*	1	1				1	1		
H	Pyrginae	*Staphylus sp (a)*	1	1	1			1			
H	Pyrginae	*Staphylus vulgata*	1	1							
H	Pyrginae	*Xenophanes tryxus (A)*	1	1							
H	Uncertain	*Unknown 3*		1							
H	Hesperiinae	*Unknown 4*		1							
H	Uncertain	*Unknown 5*		1							
L	Polyommatinae	*Cupido comyntas (A)*		1				1			
L	Polyommatinae	*Hemiargus ceraunus (a)*		1	1	1	1	1			1
L	Polyommatinae	*Leptotes cassius (a)*		1			1	1			1
L	Theclinae	*Arawacus sito*		1				1	1		
L	Theclinae	*Arawacus? similar*		1							
L	Theclinae	*Calycopis isobeon (A)*	1	1				1			1
L	Theclinae	*Calycopis sp*		1							
L	Theclinae	*Chlorostrymon simaethis*						1			
L	Theclinae	*Cyanophrys sp*		1							
L	Theclinae	*Electrostrymon joya*	1					1			
L	Theclinae	*Electrostrymon sangala*						1			
L	Theclinae	*Ministrymonsp (a)*					1				
L	Theclinae	*Oenomaus ortygnus {close]*	1								
L	Theclinae	*Panthiades bathildis (A)*						1			
L	Theclinae	*Panthiades bitias (A)*							1		
L	Theclinae	*Parrhasius polibetes (A)*		1							
L	Theclinae	*Pseudolycaena damo (A)*	1	1				1	1		
L	Theclinae	*Rekoa palegon*					1	1			1

L	Theclinae	*Rekoa zebina*						1			
L	Theclinae	*Strymon ?bebrycia*			1		1				
L	Theclinae	*Strymon istapa*				1		1			
L	Theclinae	*Strymon yojoa*				1					1
L	Theclinae	*Strymon ziba*		1	1		1				
L	Theclinae	*Theritas theocritus*		1							
L	Theclinae	*Tmolus echion (A)*					1	1			
N	Apaturinae	*Doxocopa callianira (A)*		1	1						
N	Apaturinae	*Doxocopa laure (A)*		1							
N	Charaxinae	*Archaeoprepona demophon (A)*		1	1		1	1			1
N	Charaxinae	*Consul fabius (A)*	1	1							
N	Charaxinae	*Memphis oenomais*							1	1	
N	Charaxinae	*Siderone galanthis*				1					1
N	Charaxinae	*Zaretis ellops (A)*	1	1				1			1
N	Charaxinae	*Zaretis isidora (A)*	1				1	1			
N	Danainae	*Danaus eresimus (A)*	1	1							
N	Danainae	*Danaus plexippus (A)*				1			1	1	
N	Danainae	*Lycorea halia (A)*	1	1				1			
N	Danainae	*Greta morgane oto (A)*	1	1							
N	Danainae	*Mechanitis polymnia (A)*	1	1	1			1			
N	Danainae	*Oleria paula*		1							
N	Heliconiinae	*Euptoieta hegesia (A)*	1	1	1		1	1	1		1
N	Heliconiinae	*Agraulis vanilla (A)*	1			1		1	1		
N	Heliconiinae	*Dryadula phaetusa (A)*	1	1	1	1			1		
N	Heliconiinae	*Dryas iulia (A)*	1	1	1	1	1	1	1	1	1
N	Heliconiinae	*Eueides isabella (A)*						1			
N	Heliconiinae	*Heliconius charitonia (A)*	1	1	1	1	1	1	1	1	1
N	Heliconiinae	*Heliconius erato (A)*	1	1	1	1	1	1	1	1	1
N	Heliconiinae	*Heliconius hecale (A)*	1	1	1			1			1

N	Limenitidinae	*Adelpha iphicleola (a)*	1	1		1	1				
N	Limenitidinae	*Adelpha lycorias (melanthe) (A)*		1				1			
N	Nymphalinae	*Callicore pitheas (A)*	1	1	1			1			1
N	Nymphalinae	*Dynamine postverta (A)*	1	1				1			1
N	Nymphalinae	*Epiphile adrasta*		1							
N	Nymphalinae	*Eunica monima (A)*	1	1	1		1	1	1	1	1
N	Nymphalinae	*Hamadryas amphinome (A)*		1							1
N	Nymphalinae	*Hamadryas februa (A)*	1	1	1	1	1	1	1	1	1
N	Nymphalinae	*Hamadryas glauconome (A)*	1	1	1	1	1	1	1	1	1
N	Nymphalinae	*Hamadryas guatemelena (A)*		1	1				1		1
N	Nymphalinae	*Mestra dorcas (amymone) (A)*	1	1		1	1	1	1		1
N	Nymphalinae	*Myscelia ethusa (A)*	1	1	1	1	1	1	1	1	1
N	Nymphalinae	*Nica flavilla (A)*	1	1	1			1			1
N	Nymphalinae	*Pyrrhogyra nearea*		1	1			1		1	
N	Nymphalinae	*Temenis laothoe (A)*		1	1		1	1	1		1
N	Nymphalinae	*Marpesia chiron (A)*	1	1				1			
N	Nymphalinae	*Marpesia petreus (A)*	1	1	1	1	1	1	1	1	1
N	Nymphalinae	*Junonia evarete (A)*	1	1	1	1	1	1	1	1	1
N	Nymphalinae	*Chlosyne lacinia (A)*	1								
N	Nymphalinae	*Chlosyne melanarge (A)*	1	1				1			
N	Nymphalinae	*Chlosyne theona costaricensis (A)*	1	1	1		1	1	1		
N	Nymphalinae	*Microtia elva (A)*	1	1							
N	Nymphalinae	*Anthanassa frisia tulcis (A)*	1	1	1	1		1	1		1
N	Nymphalinae	*Colobura dirce (A)*	1	1	1			1			1
N	Nymphalinae	*Smyrna blomfildia (A)*	1	1	1			1	1		1
N	Nymphalinae	*Anartia fatima (A)*	1	1	1		1	1	1	1	1
N	Nymphalinae	*Anartia jatrophae (A)*		1	1		1	1			1
N	Nymphalinae	*Siproeta stelenes (A)*	1	1	1	1	1	1	1	1	1
N	Satyrinae	*Caligo telamonius (A)*	1	1	1			1			

N	Satyrinae	*Dynastor darius stygianus (A)*	1		1						
N	Satyrinae	*Morpho helenor (A)*	1	1	1			1			
N	Satyrinae	*Pierella luna (A)*	1	1	1			1			
N	Satyrinae	*Cissia themis (A)*	1	1	1	1	1	1	1		1
N	Satyrinae	*Hermeuptychia hermes (A)*	1	1	1			1	1		1
N	Satyrinae	*Magneuptychia libye (A)*	1	1	1		1	1	1	1	1
N	Satyrinae	*Pareuptychia ocirrhoe*		1							
N	Satyrinae	*Taygetis laches (thamyra) (A)*	1	1	1			1			1
N	Satyrinae	*Taygetis uncinata*		1							
N	Satyrinae	*Taygetis virgilia (A)*	1	1	1			1			1
Pa	Papilioninae	*Eurytides ?epidaus, 2 species? (a)*							1	1	
Pa	Papilioninae	*Eurytides philolaus (A)*								1	
Pa	Papilioninae	*Papilio thoas (A)*	1	1		1			1		
Pa	Papilioninae	*Battus lycidas (A)*		1							
Pa	Papilioninae	*Battus polydamus (A)*	1	1	1	1	1	1	1	1	1
Pa	Papilioninae	*Parides eurimedes (A)*		1	1			1			
Pa	Papilioninae	*Parides iphidamas (A)*	1	1	?		1	1			1
Pi	Coliadinae	*Eurema arbela (A)*		1	1	1		1	1		1
Pi	Coliadinae	*Eurema elathea*	1					1	1		
Pi	Coliadinae	*Eurema daira (A)*	1	1	1	1	1	1	1	1	1
Pi	Coliadinae	*Phoebis philea (A)*		1	1			1		1	1
Pi	Coliadinae	*Phoebis sennae (A)*	1	1	1	1	1	1	1	1	1
Pi	Coliadinae	*Pyrisitia nise*	1	1	1	1	1	1	1	1	1
Pi	Coliadinae	*Pyrisitia proterpia (A)*	1	1	1	1		1	1	1	1
Pi	Pierinae	*Glutophrissa drusilla (A)*		1				1	1		
Pi	Pierinae	*Ascia monuste (A)*	1		1	1			1		1
Pi	Pierinae	*Ganyra josephina (A)*	1	1	1	1	1	1			1
Pi	Pierinae	*Itaballia demophile (A)*	1	1	1			1	1		1

Pi	Pierinae	*Pieriballia viardi (A)*		1	1						
R	Euselasiinae	*Euselasia mystica*		1				1			
R	Riodininae	*Eurybia elvina*	1	1				1			1
R	Riodininae	*Mesosemia telegone (A)*	1	1							
R	Riodininae	*Voltinia umbra*		1							
R	Riodininae	*Behemothia godmanii*		1							
R	Riodininae	*Calospila cilissa*		1							
R	Riodininae	*Nymphidium/Synargis sp (a)*				1		1		1	1
R	Riodininae	*Thisbe lycorias*	1	1	1	1	1	1	1		1
R	Riodininae	*Calephelis costaricicola (a)*		1					?		1
R	Riodininae	*Calephelis sixola*	1	1							
R	Riodininae	*Calydna sturnula*		1				1			
R	Riodininae	*Emesis mandana*		1							1
R	Riodininae	*Emesis sp (a)*		1	1						