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Butterflies (Lepidoptera: Papilionoidea) of the Southern Bolkar Mountains and Adjacent Çukurova Plain (Mersin, Türkiye): Richness and Turnover Along a 2–2200 m Elevational Gradient

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Abstract

The southern slopes of the Bolkar Mountains, in the western Bolkar massif of the central Taurus range, compress the full sequence of eastern Mediterranean vegetation zones into a short horizontal distance, yet their butterfly fauna has never been surveyed as a continuous gradient. Here the butterflies (Lepidoptera: Papilionoidea) of a 2–2200 m transect in Mersin Province, southern Türkiye, are documented, extending from the coastal Çukurova plain to the subalpine belt. Seventy-one sampling events were carried out on 58 dates between 2016 and 2024 in the districts of Toroslar, Çamlıyayla, Tarsus and Akdeniz. A total of 143 species in 70 genera, 16 subfamilies and five families were recorded, based on 832 specimens-by-locality records. Lycaenidae was the most species-rich family (55 species, 38.46%), followed by Nymphalidae (44, 30.77%), Pieridae and Hesperiidae (19 each, 13.29%) and Papilionidae (6, 4.20%). Sample coverage reached 96.7% and observed richness corresponded to 90.6% of the Chao2 estimate of 157.9 species. Richness increased with elevation and remained significant after adjustment for month of sampling (negative-binomial GLM, $\beta = +0.303$, $p < 0.001$); rarefied to equal effort, richness rose from 21.8 species in the 2–400 m belt to 92.0 in the 1501–2200 m belt. Assemblage composition differed strongly among belts (PERMANOVA, $F = 4.66$, $p < 0.001$), and beta diversity was dominated by turnover (88.8% of total Sørensen dissimilarity) rather than nestedness. Thirteen sampling events fell within Wildlife Development Areas; these were no richer than unprotected localities at comparable elevations, but less completely surveyed (sample coverage 75.5% against 96.2%). Comparison with the records compiled for the same area by Hesselbarth and co-workers, which list 126 species, showed 104 species in common; 39 species are added here and 22 historical records were not refound, giving 165 species now known from the gradient. The results identify the entire elevational sequence, rather than any single belt, as the unit of conservation interest, and the interior of the existing reserves as the most immediate survey priority.

Keywords: Papilionoidea; elevational gradient; species richness; beta diversity; turnover; protected areas; Taurus Mountains; eastern Mediterranean; Türkiye

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Academic Editor: Masahiko Kitahara

Received: 21 August 2026
Revised: 29 August 2026
Accepted: 1 September 2026
Published: 8 September 2026

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1. Introduction

Mountains concentrate ecological variation. A few hundred metres of ascent can reproduce the change in temperature and vegetation that would otherwise require hundreds of kilometres of latitude, and elevational gradients have accordingly become one of the standard settings in which the distribution of biodiversity is examined [1]. For insects,

and for butterflies in particular, such gradients are attractive study systems: the taxonomy is comparatively stable, the adults are diurnal and readily surveyed, and species differ sharply in their thermal and larval host-plant requirements, so that assemblages turn over rapidly with elevation [2].

Butterflies are also among the few invertebrate groups for which long-term change can be documented, and the evidence assembled over recent decades points to widespread decline, driven principally by agricultural intensification, land abandonment and climate change [3,4]. The evidence is fullest for Europe, but comparable declines have been reported wherever systematic monitoring has been sustained: twenty-one years of standardised monitoring in Ohio, USA, recorded a 2% annual fall in total butterfly abundance, a cumulative reduction of 33%, with three times as many species declining as increasing, at rates matching those of long-term European schemes [5]. The geographic bias in this evidence lies in the distribution of monitoring effort rather than in the distribution of decline, and large regions, including much of Asia, remain without comparable baselines. A recent global synthesis of 1758 species from 105 countries found that most documented range shifts, and almost four-fifths of those for which a driver could be identified, were associated with climate change and extreme weather [6]. Mediterranean mountains are of particular concern in this context: roughly two-thirds of all butterfly species are primarily mountain-dwelling, and mountain climates are eroding rapidly, so that high-elevation faunas have progressively less space into which to move [6], a process already documented as an upward displacement of elevational limits in Mediterranean mountain butterflies [7]. Baseline inventories against which such change can be measured are therefore not merely descriptive: they are the reference points without which decline cannot be detected.

Türkiye occupies a position of exceptional biogeographic importance, at the junction of the Euro-Siberian, Mediterranean and Irano-Turanian regions, and its butterfly fauna is correspondingly rich: some 380 species are known from the country [8], against 496 for the whole of Europe [9]. A substantial proportion of these are restricted to Anatolia, and the Polyommatus (Agrodiaetus) species group in particular has one of its principal centres of diversity in the Anatolian mountains [10,11]. Despite this, the distribution of many Turkish species remains imperfectly known, and quantitative studies of how butterfly assemblages are organised along environmental gradients are scarce; the greater part of the Turkish literature consists of locality-based faunistic lists [12–17].

The Taurus range, which runs parallel to the Mediterranean coast of southern Anatolia, is among the most important of these mountain systems. Its Bolkar massif culminates at 3524 m on Medetsiz Tepe, some 65 km from the coast, so that the full sequence of eastern Mediterranean vegetation belts—from coastal agricultural plain through maquis and Pinus–Quercus forest to Cedrus libani forest and subalpine grassland—is compressed into a short horizontal distance. Butterflies have been surveyed at several points in the central Taurus, including the Göksu valley at Mut [13], the western Taurus at Anamur and Bozyazı [14] and the northern flank of the Bolkar massif at Darboğaz [16], but each of these covered only part of the elevational range, and none extended to the coastal plain. The southern slope of the Bolkar Mountains, together with the adjoining Çukurova lowlands, has not previously been surveyed as a continuous gradient.

The present study addresses that gap. Between 2016 and 2024, butterflies were surveyed at 71 sampling events distributed along a continuous transect from the coastal plain at 2 m to the subalpine belt at 2200 m in Mersin Province, southern Türkiye. Part of the area lies within the Cehennem Deresi and Kadıncık Vadisi Wildlife Development Areas, which allows the contribution of the existing reserve network to be examined directly. The specific aims were:

(i) to document the butterfly fauna of the gradient and to assess how complete the resulting inventory is;
(ii) to test whether species richness varies with elevation once differences in sampling effort and season are taken into account;
(iii) to determine whether assemblages change along the gradient through the replacement of species or through their progressive loss, and to identify the species characteristic of each elevational belt;
(iv) to compare richness and inventory completeness inside and outside the protected areas of the study region.

2. Materials and Methods

2.1. Study Area

The study was carried out on the southern slopes of the Bolkar Mountains, the western Bolkar massif of the central Taurus range, and on the adjacent Çukurova plain, in Mersin Province, southern Türkiye (Figure 1). Sampling localities fall within the districts of Toroslar, Çamlıyayla, Tarsus and Akdeniz, between 36.786° and 37.336° N and 34.243° and 34.896° E, and span an elevational range of 2–2200 m a.s.l. The gradient rises from the Mediterranean coast to the subalpine belt over a horizontal distance of approximately 60 km, so that the full sequence of eastern Mediterranean vegetation zones is compressed into a comparatively small area.

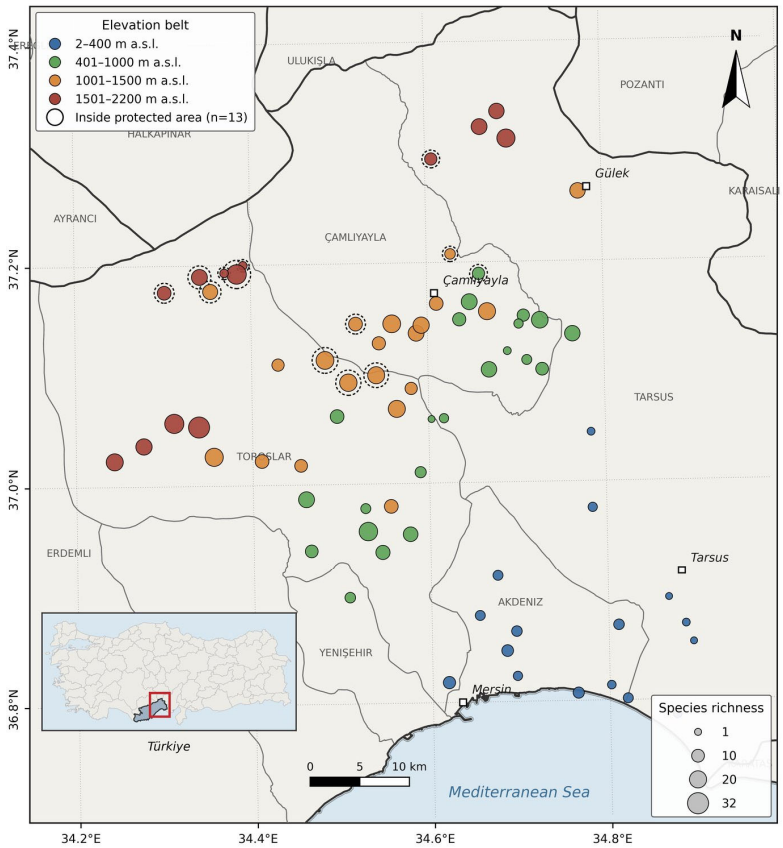

Figure 1. Study area and sampling localities in the southern Bolkar Mountains and the adjacent Çukurova plain, Mersin Province, southern Türkiye. The inset in the lower left shows the position of the study area (red outline) within Türkiye, on the southern flank of the central Taurus range; Mersin Province is shaded. The main panel shows the 71 sampling localities; colours denote the elevational belt in which each locality lies and symbol size is proportional to the number of species recorded there. Dashed rings mark the 13 localities lying within Wildlife Development Areas (Section 2.1). District boundaries are shown in grey and provincial boundaries in black. Coordinates are given on the WGS84 datum.

The region lies within the Mediterranean bioclimatic zone, with mild, rainy winters and hot, dry summers. Mean annual temperature ranges from 14 to 20 °C along the coastal belt, mean January temperature from 5 to 10 °C and mean July temperature above 25 °C, with recorded maxima reaching 45 °C. Annual precipitation ranges from 600 to 1200 mm and exceeds 1000 mm along the coast and on the south-facing slopes of the Taurus, where the study transect lies. Relative humidity remains above 60% throughout the summer and may reach 90%, which reduces transpiration in the coastal belt [18]. The valleys of the Berdan, Cehennemdere and Cocakdere rivers dissect the gradient and provide permanent water and mesic microhabitats within an otherwise summer-dry landscape. Representative habitats of the four elevational belts are shown in Figure 2.

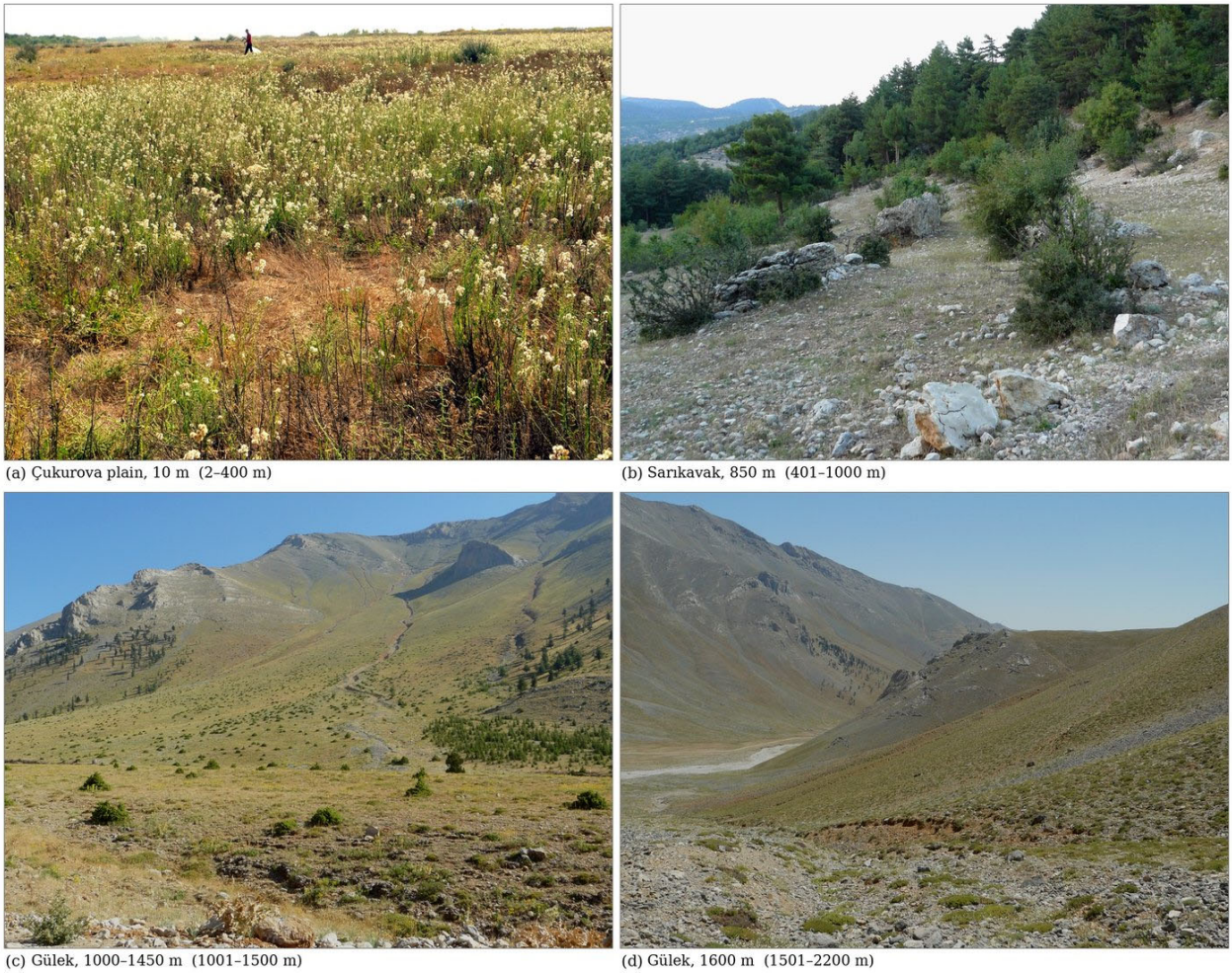

Figure 2. Representative habitats along the elevational gradient of the southern Bolkar Mountains and the adjacent Çukurova plain. (**a**) Lowland old-field grassland on the Çukurova plain, 10 m, with a collector for scale; (**b**) *Pinus* woodland edge over rocky limestone grassland at Sarıkavak, 850 m; (**c**) open grassland with scattered juniper below limestone ridges at Gülek, 1000–1450 m; (**d**) subalpine limestone scree with sparse cushion vegetation at Gülek, 1600 m. Elevational belts as defined in Section 2.1.

Following Atalay [18], the vegetation of the region falls into two main formations: a lower belt of typical Mediterranean vegetation dominated by Pinus brutia and maquis, and an upper, oro-Mediterranean belt of coniferous forest composed of Pinus nigra, Cedrus libani and Abies cilicica. Within this framework four elevational belts were distinguished for the purposes of the present study:

(i) 2–400 m—coastal and lowland agricultural landscape of the Çukurova plain, with irrigated cultivation, field margins, ruderal patches and riparian strips;
(ii) 401–1000 m—Mediterranean maquis and degraded *Quercus* scrub with *Pinus brutia*, interspersed with olive groves and small-scale cultivation;
(iii) 1001–1500 m—transition from *Pinus brutia* to *Pinus nigra* forest, with clearings, forest edges and grazed openings;
(iv) 1501–2200 m—oro-Mediterranean coniferous forest of *Cedrus libani* and *Abies cilicica*, grading into subalpine grassland and rocky steppe above the treeline.

Thirteen of the sampling localities lie within Wildlife Development Areas (Yaban Hayatı Geliştirme Sahası). This is a protected-area category defined by the Terrestrial Hunting Law No. 4915 of 2003 and its implementing regulation, and administered by the General Directorate of Nature Conservation and National Parks of the Ministry of Agriculture and Forestry. Such areas are designated for the protection and management of game and wildlife: habitat improvement measures are undertaken, game species may be introduced, and hunting is prohibited except where a special hunting plan has been approved. Within their boundaries wildlife may not be destroyed and the ecosystem may not be degraded; installations liable to affect the area adversely are not permitted, no structure may be erected outside an approved management plan, and easement rights may not be established. The category is distinct from the more strictly protected Wildlife Protection Area (yaban hayatı koruma sahası), in which absolute protection applies. Designation rests on one or more target species, which in practice are large mammals or birds; invertebrates are not considered in the designation process, and butterflies benefit only incidentally, through the habitat protection afforded to the target species. The two areas represented in the present survey, Cehennem Deresi and Kadıncık Vadisi, lie entirely above 1000 m.

The districts given in Table 1 are civil administrative districts. The forestry administration of the protected areas follows a different division, so that localities recorded here in the Toroslar and Çamlıyayla districts fall under the Tarsus Forest Enterprise Directorate.

Table 1. Sampling localities in the southern Bolkar Mountains and adjacent Çukurova plain, Mersin Province, Türkiye. Coordinates are given in decimal degrees (WGS84).

No	District	Locality	Elev. (m)	Belt (m)	Date	Latitude (°N)	Longitude (°E)
1	Toroslar	Soğucak	900	401–1000	26 May 2016	36.93778	34.54556
2	Toroslar	Cocakdere, valley	1500	1001–1500	29 May 2016	37.17639	34.35417
3	Toroslar	Cocakdere, K. A.	1650	1501–2200	29 May 2016	37.19972	34.39167
4	Toroslar	Cocakdere, Tepe	1700	1501–2200	30 May 2016	37.19194	34.38444
5	Toroslar	Cocakdere, Teke	2100	1501–2200	30 May 2016	37.19306	34.37028
6	Çamlıyayla	Ulumeres	1000	401–1000	11 June 2016	37.16389	34.64806
7	Çamlıyayla	Fakılar	1000	401–1000	12 June 2016	37.18944	34.65917
8	Tarsus	Böğrüeğri	1060	1001–1500	20 June 2016	37.08611	34.58056
9	Tarsus	Böğrüeğri W.	1100	1001–1500	23 June 2016	37.06778	34.56389
10	Akdeniz	Karaduvar	10	2–400	25 July 2016	36.82306	34.69583
11	Toroslar	Bekiralanı	950	401–1000	2 July 2016	36.97778	34.52694
12	Toroslar	Aladağ	900	401–1000	15 July 2016	36.93972	34.46500
13	Toroslar	Çukurkeşlik	500	401–1000	12 November 2016	36.89639	34.50778
14	Tarsus	Böğrüeğri S.	700	401–1000	1 June 2017	37.05861	34.61722
15	Çamlıyayla	Tepensesi	1120	1001–1500	1 June 2017	37.16278	34.61056
16	Tarsus	Böğrüeğri SE.	730	401–1000	2 June 2017	37.05806	34.60306
17	Çamlıyayla	Zinat	1900	1501–2200	9 June 2017	37.29389	34.60722

Table 1. *Cont.*

No	District	Locality	Elev. (m)	Belt (m)	Date	Latitude (°N)	Longitude (°E)
18	Toroslar	Yeniköy	750	401–1000	10 July 2017	36.98667	34.46000
19	Çamlıyayla	Sebil N.	1200	1001–1500	18 July 2017	37.14500	34.55972
20	Tarsus	Gülek, Karboğazı	1800	1501–2200	16 August 2017	37.31167	34.69306
21	Tarsus	Karboğazı N.	2000	1501–2200	19 August 2017	37.32250	34.66278
22	Tarsus	Gülek, Ardıçlı	2200	1501–2200	22 August 2017	37.33639	34.68278
23	Tarsus	Gülek	1200	1001–1500	26 August 2017	37.26306	34.77333
24	Toroslar	Kurudere	1200	1001–1500	20 April 2018	37.02194	34.41028
25	Toroslar	Kepirli	900	401–1000	23 April 2018	36.95694	34.52944
26	Toroslar	Darısekisi	1100	1001–1500	15 May 2018	36.97944	34.55583
27	Çamlıyayla	Darıpınarı	550	401–1000	19 May 2018	37.14639	34.72778
28	Çamlıyayla	Giden	900	401–1000	22 May 2018	37.11056	34.71222
29	Çamlıyayla	Yalamık	800	401–1000	25 May 2018	37.13361	34.76444
30	Çamlıyayla	Korucak	850	401–1000	25 May 2018	37.15083	34.70917
31	Çamlıyayla	Korucak S.	850	401–1000	31 May 2018	37.14333	34.70361
32	Çamlıyayla	Sarıkoyak	850	401–1000	31 May 2018	37.10194	34.72944
33	Çamlıyayla	Sarıkavak	1000	401–1000	31 May 2018	37.11889	34.69028
34	Toroslar	Tırtar N.	1600	1501–2200	11 July 2018	37.05361	34.33944
35	Toroslar	Dümbelek	1900	1501–2200	11 July 2018	37.05722	34.31139
36	Toroslar	Güzelyayla	900	401–1000	15 July 2018	37.06167	34.49611
37	Toroslar	Hisarkale	1300	1001–1500	15 July 2022	37.01750	34.45444
38	Toroslar	Alanyalı	1300	1001–1500	15 July 2022	37.09222	34.50944
39	Toroslar	Alanyalı W.	1400	1001–1500	15 July 2022	37.11278	34.48333
40	Toroslar	Atlılar N.	1450	1001–1500	15 July 2022	37.10917	34.43000
41	Toroslar	Evrenli	600	401–1000	19 May 2022	36.95389	34.57722
42	Toroslar	Tırtar	1400	1001–1500	11 July 2022	37.02639	34.35611
43	Toroslar	Arslanköy N.	1800	1501–2200	11 July 2022	37.03667	34.27667
44	Toroslar	Kızılkaya	1200	1001–1500	17 July 2022	37.09861	34.54111
45	Çamlıyayla	Sarıkavak S.	800	401–1000	28 June 2023	37.10222	34.66917
46	Çamlıyayla	Belçınar	1100	1001–1500	30 June 2023	37.15500	34.66806
47	Çamlıyayla	Sebil	1100	1001–1500	7 July 2023	37.12750	34.54472
48	Çamlıyayla	Cehennemdere	1050	1001–1500	10 July 2023	37.14528	34.51861
49	Çamlıyayla	Sebil E.	1020	1001–1500	10 July 2023	37.13611	34.58722
50	Toroslar	Arslanköy W.	1800	1501–2200	19 August 2023	37.02306	34.24333
51	Akdeniz	Huzurkent	10	2–400	24 October 2023	36.86806	34.81111
52	Tarsus	Yeşiltepe N.	10	2–400	4 November 2023	36.85222	34.89556
53	Akdeniz	Deliçay	80	2–400	25 Mar 2024	36.91444	34.67528
54	Toroslar	Gözne	950	401–1000	28 Mar 2024	37.01000	34.58972
55	Tarsus	Çavdarlı W.	350	2–400	21 April 2024	37.04444	34.78361
56	Tarsus	Dedeler	280	2–400	30 April 2024	36.97583	34.78389
57	Akdeniz	Dikilitaş	40	2–400	1 May 2024	36.86361	34.69556
58	Akdeniz	Çay	50	2–400	11 May 2024	36.84611	34.68472
59	Toroslar	Mevlana	100	2–400	28 May 2024	36.81806	34.61833
60	Çamlıyayla	Ergene	950	401–1000	9 June 2024	37.14806	34.63639
61	Çamlıyayla	Çıkrıcak	1200	1001–1500	15 June 2024	37.20750	34.62722
62	Toroslar	Cocakdere, M. P.	1650	1501–2200	1 July 2024	37.17583	34.30194
63	Toroslar	Cocakdere, Anıt	2100	1501–2200	1 July 2024	37.18972	34.34222
64	Çamlıyayla	Sebil W.	1100	1001–1500	15 July 2024	37.14333	34.59306
65	Akdeniz	Adanalıoğlu	5	2–400	30 August 2024	36.80139	34.82000

Table 1. *Cont.*

No	District	Locality	Elev. (m)	Belt (m)	Date	Latitude (°N)	Longitude (°E)
66	Tarsus	Kulak	10	2–400	30 August 2024	36.78639	34.87556
67	Akdeniz	Kazanlı	2	2–400	9 October 2024	36.80694	34.76417
68	Akdeniz	Adanalıoğlu, Limonlu	2	2–400	16 October 2024	36.81361	34.80167
69	Akdeniz	Bekirde	50	2–400	12 November 2024	36.87833	34.65444
70	Tarsus	Karabucak	10	2–400	21 September 2024	36.86889	34.88722
71	Tarsus	Karabucak N.	10	2–400	11 October 2024	36.89278	34.86833

Localities 2, 3, 4, 5, 7, 17, 38, 39, 44, 48, 61, 62 and 63 lie within Wildlife Development Areas (Section 2.1).

2.2. Sampling Design and Field Effort

Butterflies were surveyed by active searching combined with hand-netting using an aerial net. Each sampling event consisted of a single day's survey of one locality, beginning in the early morning and continuing until the late afternoon, and covered all accessible microhabitats present at the site, including open grassland, forest edges and clearings, streambanks and riparian strips, rocky outcrops and nectar-rich patches. Surveys were conducted only under warm, sunny and calm weather. Voucher specimens were retained for every species encountered, so that all records could subsequently be verified in the laboratory; consequently, all 143 species reported here are represented by preserved material and remain available for re-examination.

Survey duration was not held constant and varied among sampling events with terrain, weather and accessibility. Sampling effort was therefore not standardised in the sense of a fixed-length transect or a fixed-duration protocol, and the number of specimens obtained per species reflects collecting decisions rather than relative abundance in the field. For this reason all analyses reported below are based on species incidence (presence/absence) per sampling event, and no abundance-based diversity indices were calculated (Section 2.6).

Where two or more localities, often at different elevations, were surveyed on the same date, each was treated as a separate sampling event. A single sampling event covered the accessible habitats within and around the recorded locality rather than a single point, so the coordinates in Table 1 should be understood as the approximate centre of the area searched, and the assignment of localities to protected areas is correspondingly approximate at their margins. A total of 71 sampling events were carried out at 71 localities on 58 field dates between May 2016 and November 2024. Twenty-eight sampling events fell in Toroslar, 20 in Çamlıyayla, 14 in Tarsus and 9 in Akdeniz. Fieldwork was conducted in 2016–2018 and 2022–2024; no surveys were undertaken between 2019 and 2021, owing to restrictions during the COVID-19 pandemic and to periodic local restrictions on access to forested land during high fire-risk periods. Fieldwork in early spring was in any case limited throughout the study by prolonged cloud and rain and by snow cover at higher elevations, which restricts survey opportunities in March and April. The distribution of sampling effort among years, months and elevational belts is given in Table 2.

Two features of Table 2 constrain the interpretation of the results and are addressed in Sections 2.6 and 4.6. First, effort was unevenly distributed among belts, with 16, 22, 20 and 13 sampling events in the four belts respectively. Second, effort was concentrated in May and July, and September is represented by a single event and March by two, so that species numbers recorded in those months measure effort as much as phenology.

Table 2. Distribution of sampling effort (number of sampling events) among years, months and elevational belts.

	2–400 m	401–1000 m	1001–1500 m	1501–2200 m	Total
2016	1	6	3	3	13
2017	0	3	3	4	10
2018	0	9	2	2	13
2022	0	1	6	1	8
2023	2	1	4	1	8
2024	13	2	2	2	19
Total	16	22	20	13	71
March	1	1	0	0	2
April	2	1	1	0	4
May	3	9	2	3	17
June	0	6	5	1	12
July	1	4	11	5	21
August	2	0	1	4	7
September	1	0	0	0	1
October	4	0	0	0	4
November	2	1	0	0	3

Upper block, sampling events per year; lower block, the same 71 events summarised by month.

2.3. Field Recording and Data Structure

For every record the following data were entered on a standardised specimen label and in a parallel digital database: locality name, district, geographic coordinates, elevation (m a.s.l.), date, collector and a short description of the microhabitat. Coordinates were obtained in the field with a Garmin GPSMAP 64sx receiver (Garmin Ltd., Olathe, KS, USA; nominal accuracy ±5 m), are reported in decimal degrees on the WGS84 datum and are listed in Table 1. Elevations were read from the same receiver.

The sampling unit used in all analyses was the sampling event, defined as a single survey of one locality on one date. The complete record-level dataset, comprising one row per species per sampling event, is provided as Supplementary Material File S1.

2.4. Specimen Preparation and Deposition

Retained specimens were killed in ethyl acetate vapour and transported in paper envelopes. In the laboratory they were first held at −45 °C in a deep freezer (Uğur Soğutma A.Ş., Nazilli, Aydın, Türkiye) to eliminate parasites, then pinned with entomological pins, set with the wings spread on setting boards using tracing paper, and dried in a drying oven (Nüve Sanayi Malzemeleri İmalat ve Ticaret A.Ş., Ankara, Türkiye) at 65 °C for 24 h. Dried specimens were provided with printed labels on archival-quality paper. All material is deposited in the Entomological Research Laboratory (ENTOLAB), Department of Biology, Mersin University, Mersin, Türkiye, and is available for study upon request.

2.5. Identification and Taxonomy

Specimens were examined under an Olympus SZ51 stereomicroscope (Olympus Corporation, Tokyo, Japan). Hesselbarth, van Oorschot and Wagener [19] was used as the primary regional reference, with Hofmann and Marktanner [20] as a supplementary field guide; nomenclature and the sequence of higher taxa follow Wiemers et al. [9] and, at the level of superfamilies, van Nieukerken et al. [21]. Hesperiidae are treated within Papilionoidea following Heikkilä et al. [22]. Critical specimens were re-examined repeatedly

over an extended period, compared with authenticated material in the ENTOLAB collection, and cross-checked against the online resources Lepidoptera Mundi [23] and Lepiforum [24].

Genitalic dissection was not undertaken in the present study. Records of taxa that cannot be separated with confidence on external characters are therefore treated as provisional. This applies to the genera *Polyommatus* (with the exception of the widespread and unmistakable *P. icarus*), *Kretania* and *Pyrgus*, but the reasons differ among these groups. In *Kretania* and *Pyrgus*, species limits rest largely on genitalic characters, which were not examined here. In *Polyommatus*, and particularly in the *Agrodiaetus* species group, genitalic morphology is of limited diagnostic value: species are delimited primarily by karyotype, chromosome numbers varying widely among closely related and externally near-identical taxa, and by molecular markers [10,11]. In all three groups wing-pattern variation within populations may exceed the differences between species. Twenty-seven of the 143 species are so treated; they are flagged in the systematic checklist, are excluded from the indicator species analysis (Section 2.6) and from any inference about endemism or conservation priority, and require confirmation by karyological or molecular examination, supplemented where appropriate by genitalic dissection. Because all material is preserved as vouchers in ENTOLAB, these identifications remain open to verification.

2.6. Data Analysis

All analyses were based on species incidence per sampling event and were carried out in Python 3.12 (Python Software Foundation, Wilmington, DE, USA) using NumPy and SciPy. Each estimator was implemented directly from its primary source rather than through a package, and the complete analysis code is provided as Supplementary Material File S2, so that every value reported below can be reproduced and checked against the published formulae.

Inventory completeness. Sample-based species accumulation was assessed by incidence-based rarefaction, computed exactly by the hypergeometric formulation of Colwell et al. [25]. Asymptotic richness was estimated with the Chao2 estimator [26], and the completeness of the inventory was expressed as sample coverage [27]. Curves and estimates were computed for the whole study area and separately for each elevational belt.

Richness along the elevational gradient. Because effort differed among belts and months (Table 2), observed richness was not compared directly: richness was compared after rarefaction to a common number of sampling events, taken as the number available in the least-sampled belt (13 events). The relationship between per-event richness and elevation was modelled with a generalised linear model with negative-binomial errors, the data being overdispersed relative to a Poisson expectation. Elevation was fitted alone and then with month as a covariate, and the contribution of month was assessed by a likelihood-ratio test.

Compositional turnover. Pairwise dissimilarity between sampling events was calculated with the Sørensen index and partitioned into its turnover and nestedness components following Baselga [28]. Differences in composition among elevational belts, months and districts were tested by permutational multivariate analysis of variance with 4999 permutations [29]. The relationship of dissimilarity to elevational difference and to geographic distance was examined with Spearman rank correlations.

Indicator species. Species characteristic of individual belts were identified by indicator value analysis [30], with significance assessed by 999 permutations of the belt labels. Provisional records (Section 2.5) were excluded.

Protected areas. Richness inside and outside the protected areas was compared after rarefaction to a common number of sampling events and, because all protected localities lie

above 1000 m, also within the subset of events above that elevation. Per-event richness was compared with a Mann–Whitney U test.

2.7. Permits and Ethical Statement

Collecting permits are not required for invertebrates in Türkiye. Fieldwork within the Cehennem Deresi and Kadıncık Vadisi Wildlife Development Areas was carried out with the knowledge of, and in part accompanied by staff of, the Tarsus Forest Enterprise Directorate, for which the author also acts as a consultant on the identification of confiscated Lepidoptera material. Individuals not required as vouchers were identified in the field, photographed where possible and released unharmed. The study involved no vertebrates.

3. Results

3.1. Sampling Effort and Inventory Completeness

Seventy-one sampling events were carried out on 58 dates between 2016 and 2024 at localities distributed across four districts of Mersin Province and spanning 2–2200 m a.s.l. (Table 1, Figure 1). Effort was unevenly distributed among elevational belts, with 16, 22, 20 and 13 events in the 2–400, 401–1000, 1001–1500 and 1501–2200 m belts respectively, and among months, with the greatest effort in July (21 events) and May (17) and only single events in September and two in March (Table 2).

A total of 143 species were recorded, represented by 832 specimens-by-locality records. Species richness accumulated steeply over the first 20 sampling events and continued to rise slowly thereafter without reaching an asymptote (Figure 3a). Rarefaction indicated that 94.2 species would be expected from 20 events and 123.5 from 40, against 143 from the full set of 71. The Chao2 estimator gave an asymptotic richness of 157.9 species, implying that approximately 15 species remain undetected. Sample coverage reached 96.7%, and observed richness corresponded to 90.6% of the Chao2 estimate. Twenty-eight species (19.6%) were recorded from a single locality and 21 species from ten or more.

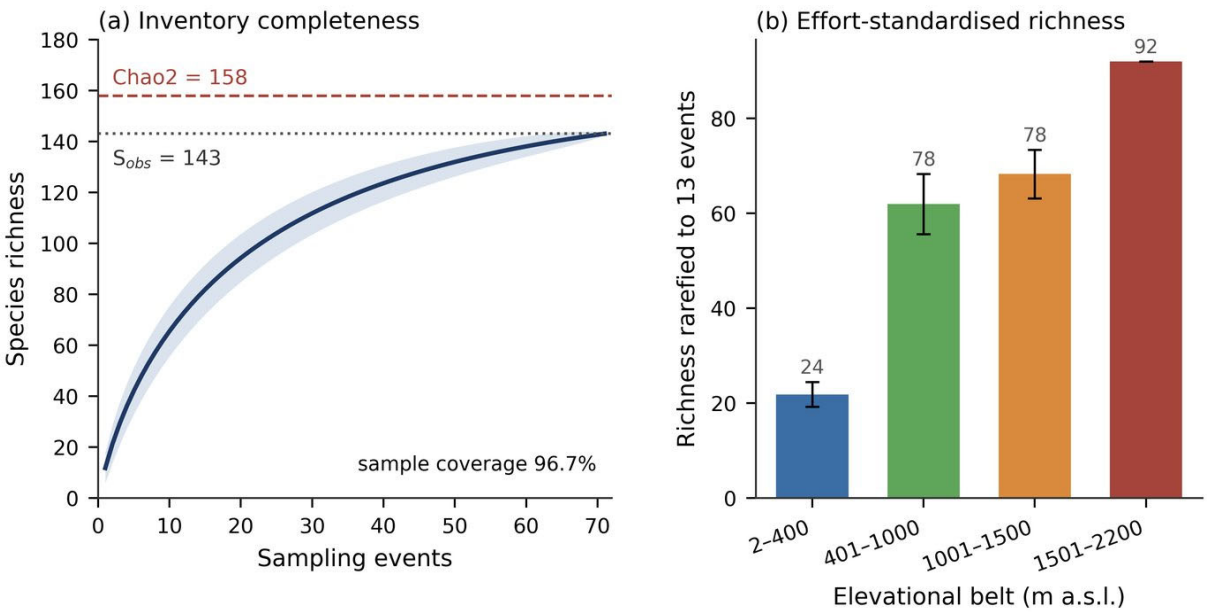

Figure 3. (**a**) Sample-based rarefaction curve with 95% confidence band, showing observed richness and the Chao2 estimate; (**b**) richness rarefied to 13 sampling events per elevational belt, with observed richness given above each bar. The 1501–2200 m belt comprises exactly 13 events and therefore defines the reference point, so its rarefied value equals its observed value. The shaded band is the 95% confidence interval of the rarefaction curve.

3.2. Taxonomic Composition

The 143 species belong to 70 genera, 16 subfamilies and five families. Lycaenidae was the most species-rich family with 55 species (38.46% of the total) in 22 genera, followed by Nymphalidae with 44 species (30.77%) in 25 genera, Pieridae and Hesperiidae with 19 species each (13.29%) in eight and ten genera respectively, and Papilionidae with six species (4.20%) in five genera (Table 3). *Polyommatus* was the richest genus with 19 species.

Table 3. Family-level composition of the butterfly fauna of the study area.

Family	Subfamilies	Genera	Species	% of Total
Papilionidae	2	5	6	4.20%
Pieridae	3	8	19	13.29%
Nymphalidae	6	25	44	30.77%
Lycaenidae	3	22	55	38.46%
Hesperiidae	2	10	19	13.29%
Total	16	70	143	100.00%

The most widely distributed species were *Polyommatus icarus* (42 localities), *Colias croceus* and *Pieris rapae* (38 each), *Vanessa cardui* (31) and *Pontia edusa* (30). The complete checklist, with locality records for every species, is given in Table 4.

Table 4. Systematic checklist of the 143 butterfly species recorded, with the sampling events at which each was found. Locality numbers correspond to Table 1.

Family	Subfamily	Species	Author	Localities	n
Papilionidae Latreille, [1802]	Papilioninae	*Iphiclides podalirius*	(Linnaeus, 1758)	26, 29, 32, 37, 42, 44, 49	7
		Papilio machaon	Linnaeus, 1758	5, 14, 24, 32, 61	5
	Parnassiinae	*Parnassius mnemosyne*	(Linnaeus, 1758)	4, 15, 26, 29, 35	5
		Archon apollinus	(Herbst, 1798)	28, 46, 61	3
		Zerynthia cerisy	(Godart, [1824])	9, 26, 29, 46, 47	5
		Zerynthia deyrollei	(Oberthür, 1869)	9, 30, 61	3
Hesperiidae Latreille, 1809	Hesperiinae	*Pelopidas thrax*	(Hübner, [1821])	50, 59, 67, 68	4
		Gegenes pumilio	(Hoffmannsegg, 1804)	4	1
		Ochlodes sylvanus	(Esper, 1777)	45	1
		Hesperia comma	(Linnaeus, 1758)	21, 22	2
		Thymelicus acteon	(Rottemburg, 1775)	6, 9, 19, 26, 27, 38, 39, 42, 44, 49, 64	11
		Thymelicus hyrax	(Lederer, 1861)	2, 3, 4, 8, 25, 26, 27, 29, 32, 38, 42, 44, 49, 62	14
		Thymelicus sylvestris	(Poda, 1761)	23, 34, 35, 39, 42, 43, 44, 62	8
		Thymelicus lineola	(Ochsenheimer, 1808)	6, 18, 34, 39, 42, 44, 49, 62	8
	Pyrginae	*Spialia orbifer*	(Hübner, [1823])	3, 4, 8, 20, 25, 26, 27, 34, 38, 42, 44, 45, 48, 49, 62	15
		Carcharodus alceae	(Esper, [1780])	19, 25, 27, 34, 35, 38, 41, 42, 45, 48, 50	11

Table 4. *Cont.*

Family	Subfamily	Species	Author	Localities	n
		Muschampia tessellum	(Hübner, [1803])	50, 62	2
		Carcharodus orientalis	Reverdin, 1913	4, 25, 39, 42, 44, 67	6
		Carcharodus stauderi	Reverdin, 1913	4	1
		Erynnis tages	(Linnaeus, 1758)	5, 39, 60	3
		Pyrgus sidae †	(Esper, 1784)	4	1
		Pyrgus serratulae †	(Rambur, 1839)	4, 62, 63	3
		Pyrgus armoricanus †	(Oberthür, 1910)	10, 18, 35, 44, 48	5
		Pyrgus melotis †	(Duponchel, [1834])	10, 25, 48	3
		Pyrgus cinarae †	(Rambur, 1839)	48	1
Pieridae Swainson, 1820	Dismorphiinae	*Leptidea duponcheli*	(Staudinger, 1871)	46, 55	2
		Leptidea sinapis	(Linnaeus, 1758)	33, 60	2
	Coliadinae	*Gonepteryx rhamni*	(Linnaeus, 1758)	27, 31	2
		Gonepteryx farinosa	(Zeller, 1847)	1, 6, 7, 25, 41, 42, 45, 46	8
		Colias alfacariensis	Ribbe, 1905	4, 19, 23, 34, 35, 43, 44, 56, 64	9
		Colias aurorina	Herrich-Schäffer, 1850	17, 20	2
		Colias croceus	(Geoffroy, 1785)	1, 4, 8, 9, 12, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 34, 36, 38, 39, 41, 42, 43, 46, 47, 48, 49, 53, 54, 57, 58, 59, 61, 64, 65	38
	Pierinae	*Aporia crataegi*	(Linnaeus, 1758)	4, 60	2
		Pontia edusa	(Fabricius, 1777)	1, 8, 9, 11, 12, 13, 15, 17, 19, 23, 26, 27, 31, 32, 34, 36, 37, 38, 39, 42, 43, 44, 45, 46, 47, 49, 57, 58, 59, 64	30
		Pieris krueperi	Staudinger, 1860	7, 16	2
		Pieris brassicae	(Linnaeus, 1758)	1, 6, 7, 11, 12, 13, 15, 19, 23, 24, 25, 26, 30, 32, 34, 36, 38, 39, 41, 42, 43, 50, 64, 69	24
		Pieris rapae	(Linnaeus, 1758)	1, 4, 6, 8, 9, 10, 12, 13, 14, 15, 23, 24, 26, 27, 28, 29, 34, 35, 36, 37, 42, 43, 44, 45, 46, 49, 51, 53, 54, 56, 57, 58, 59, 64, 65, 67, 69, 70	38
		Pieris mannii	(Mayer, 1851)	17	1
		Pieris ergane	(Geyer, [1828])	56	1
		Pieris napi	(Linnaeus, 1758)	4, 28, 35, 54	4
		Euchloe ausonia	(Hübner, [1804])	29, 30, 53, 59	4
		Anthocharis cardamines	(Linnaeus, 1758)	25, 41	2
		Anthocharis gruneri	Herrich-Schäffer, 1851	31, 61	2
		Anthocharis damone	Boisduval, 1836	25, 46, 61	3
Lycaenidae [Leach], [1815]	Lycaeninae	*Lycaena alciphron*	(Rottemburg, 1775)	2, 35, 43, 50, 63	5
		Lycaena thetis	Klug, 1834	21, 33	2
		Lycaena thersamon	(Esper, 1784)	2, 46, 47	3
		Lycaena candens	(Herrich-Schäffer, 1844)	2	1

Table 4. *Cont.*

Family	Subfamily	Species	Author	Localities	n
		Lycaena phlaeas	(Linnaeus, [1760])	7, 8, 11, 18, 25, 26, 27, 34, 38, 39, 45, 58, 60	13
		Lycaena tityrus	(Poda, 1761)	2, 63	2
	Theclinae	*Tomares nogelii*	(Herrich-Schäffer, 1851)	17	1
		Callophrys rubi	(Linnaeus, 1758)	25, 54	2
		Satyrium ilicis	(Esper, 1779)	8, 9, 29, 30, 34, 45, 48, 49	8
		Satyrium spini	([Denis & Schiffermüller], 1775)	9, 29, 30, 34, 45, 46, 48	7
	Polyommatinae	*Leptotes pirithous*	(Linnaeus, 1767)	67, 68	2
		Lampides boeticus	(Linnaeus, 1767)	1, 2, 4, 25, 26, 27, 29, 34, 40, 41, 42, 44, 51, 60, 62, 66	16
		Celastrina argiolus	(Linnaeus, 1758)	11, 34, 54, 60	4
		Pseudophilotes bavius	(Eversmann, 1832)	1, 18, 41	3
		Pseudophilotes vicrama	(Moore, 1865)	20, 21, 27	3
		Iolana iolas	(Ochsenheimer, 1816)	41	1
		Glaucopsyche alexis	(Poda, 1761)	19, 25	2
		Zizeeria karsandra	(Moore, 1865)	13, 67	2
		Cupido osiris	(Meigen, 1829)	4, 17, 20, 63	4
		Freyeria trochylus	(Freyer, 1844)	18, 19, 29, 38, 39, 40, 42, 44, 64	9
		Plebejus argus	(Linnaeus, 1758)	21, 62	2
		Plebejus idas	(Linnaeus, [1760])	62	1
		Plebejus hyacinthus	(Herrich-Schäffer, 1847)	19, 27, 31, 45, 46	5
		Plebejidea loewii	(Zeller, 1847)	21, 34, 35, 63	4
		Eumedonia eumedon	(Esper, 1780)	62	1
		Kretania eurypilos †	(Freyer, 1851)	20, 35, 50, 63	4
		Kretania sephirus †	(Frivaldszky, 1835)	15, 21, 32, 34, 35, 63	6
		Kretania alcedo †	(Christoph, 1877)	46	1
		Kretania pylaon †	(Fischer, 1832)	34, 35	2
		Cyaniris bellis	(Freyer, [1842])	15, 25, 41	3
		Cyaniris semiargus	(Rottemburg, 1775)	1, 17, 24, 25, 41	5
		Aricia anteros	(Freyer, 1838)	6, 25, 41	3
		Aricia artaxerxes	(Fabricius, 1793)	29	1
		Aricia agestis	([Denis & Schiffermüller], 1775)	9, 18, 24, 25, 27, 30, 34, 38, 39, 40, 42, 43, 45, 49, 50, 58, 59	17
		Neolysandra coelestina	(Eversmann, 1843)	4	1
		Lysandra bellargus	(Rottemburg, 1775)	2, 3, 4, 15, 17, 20, 24, 29, 38, 39, 42, 60, 63	13
		Polyommatus thersites †	(Cantener, 1835)	2, 4, 18, 20, 24, 43, 46, 47, 50, 60	10
		Polyommatus daphnis †	([Denis & Schiffermüller], 1775)	2, 20, 21, 22, 35, 43, 50	7

Table 4. *Cont.*

Family	Subfamily	Species	Author	Localities	n
		Polyommatus amandus †	(Schneider, 1792)	2, 4, 15, 63	4
		Polyommatus dorylas †	([Denis & Schiffermüller], 1775)	47	1
		Polyommatus icarus	(Rottemburg, 1775)	1, 4, 6, 7, 8, 11, 12, 15, 17, 18, 19, 20, 23, 24, 25, 27, 29, 30, 32, 34, 36, 38, 39, 42, 44, 45, 46, 47, 48, 49, 50, 51, 53, 54, 57, 58, 59, 60, 63, 64, 65, 67	42
		Polyommatus actis †	(Herrich-Schäffer, 1851)	20, 22, 34	3
		Polyommatus admetus †	(Esper, 1783)	21, 34, 50	3
		Polyommatus ripartii †	(Freyer, 1830)	20, 21, 34, 35	4
		Polyommatus sertavulensis †	(Koçak, 1979)	21, 22, 35, 50	4
		Polyommatus iphigenia †	(Herrich-Schäffer, 1847)	35, 43, 50, 63	4
		Polyommatus hopfferi †	(Herrich-Schäffer, 1851)	34, 43, 50	3
		Polyommatus ossmar †	(Gerhard, [1851])	2, 4, 21, 40, 42, 50	6
		Polyommatus phyllis †	(Christoph, 1877)	22	1
		Polyommatus carmon †	(Herrich-Schäffer, 1851)	19, 64	2
		Polyommatus eroides †	(Frivaldszky, 1835)	19, 46, 49	3
		Polyommatus poseidon †	(Herrich-Schäffer, 1851)	63	1
		Polyommatus wagneri †	(Forster, 1956)	21	1
		Polyommatus syriacus †	(Tutt, [1910])	2, 4, 45	3
		Polyommatus cornelia †	(Freyer, [1850])	2, 4, 20, 22, 39, 40, 50	7
Nymphalidae Rafinesque, 1815	Limenitidinae	*Limenitis reducta*	Staudinger, 1901	2, 45, 49	3
	Heliconiinae	*Issoria lathonia*	(Linnaeus, 1758)	4, 22, 49	3
		Argynnis paphia	(Linnaeus, 1758)	6, 22, 35, 38, 39, 42, 44, 48	8
		Argynnis pandora	([Denis & Schiffermüller], 1775)	6, 9, 19, 20, 21, 22, 23, 34, 37, 38, 39, 40, 42, 50, 64	15
		Speyeria aglaja	(Linnaeus, 1758)	20, 47	2
		Fabriciana niobe	(Linnaeus, 1758)	2, 4, 34, 35, 43, 44	6
		Fabriciana adippe	([Denis & Schiffermüller], 1775)	38, 39, 44	3
	Nymphalinae	*Vanessa cardui*	(Linnaeus, 1758)	1, 9, 12, 19, 20, 21, 22, 23, 24, 25, 27, 32, 34, 35, 36, 37, 38, 39, 40, 41, 42, 49, 51, 53, 54, 57, 58, 59, 64, 65, 69	31
		Vanessa atalanta	(Linnaeus, 1758)	9, 19, 25, 35, 37, 41, 43, 51, 57, 58, 59, 63, 69	13

Table 4. *Cont.*

Family	Subfamily	Species	Author	Localities	n
		Aglais urticae	(Linnaeus, 1758)	4	1
		Polygonia c-album	(Linnaeus, 1758)	6	1
		Nymphalis polychloros	(Linnaeus, 1758)	6, 25	2
		Melitaea trivia	([Denis & Schiffermüller], 1775)	10, 12, 21, 22, 23, 24, 36, 38, 39, 42, 46, 47, 49, 66	14
		Melitaea didyma	(Esper, 1778)	9, 20, 27, 34, 35, 43, 60, 62	8
		Melitaea phoebe	([Denis & Schiffermüller], 1775)	15, 27, 40	3
		Melitaea cinxia	(Linnaeus, 1758)	5, 17, 35, 43, 62	5
		Melitaea punica	Oberthür, 1876	27, 63	2
	Libytheinae	*Libythea celtis*	(Laicharting, 1782)	28, 56	2
	Danainae	*Danaus chrysippus*	(Linnaeus, 1758)	51, 52, 65, 66, 67, 68, 69, 70, 71	9
	Satyrinae	*Coenonympha pamphilus*	(Linnaeus, 1758)	1, 6, 12, 14, 15, 18, 19, 23, 24, 25, 34, 36, 37, 38, 39, 41, 44, 50, 64	19
		Coenonympha leander	(Esper, 1784)	63	1
		Kirinia roxelana	(Cramer, 1777)	9, 18, 35, 43	4
		Pararge aegeria	(Linnaeus, 1758)	1, 7, 9, 12, 13, 18, 36	7
		Lasiommata maera	(Linnaeus, 1758)	7, 19, 20, 23, 35, 48, 64	7
		Lasiommata megera	(Linnaeus, 1767)	6, 7, 9, 13, 46, 60	6
		Melanargia larissa	(Geyer, [1828])	4, 8, 9, 18, 19, 20, 21, 22, 23, 25, 34, 37, 38, 39, 40, 44, 46, 47, 48, 49, 64	21
		Melanargia syriaca	Oberthür, 1894	19, 23, 63, 64	4
		Melanargia titea	(Klug, 1832)	45	1
		Hipparchia syriaca	(Staudinger, 1871)	6, 7, 36, 38	4
		Hipparchia statilinus	(Hufnagel, 1766)	35, 50	2
		Hipparchia mersina	(Staudinger, 1871)	6, 18, 36	3
		Brintesia circe	(Fabricius, 1775)	1, 18, 19, 37, 45, 47, 64	7
		Satyrus favonius	Staudinger, 1892	20	1
		Satyrus ferula	(Fabricius, 1793)	20	1
		Chazara briseis	(Linnaeus, 1764)	20, 23, 34, 38, 39	5
		Chazara persephone	(Hübner, [1805])	20, 22, 34	3
		Pseudochazara anthelea	(Hübner, [1824])	34, 35	2
		Pseudochazara mniszechii	(Herrich-Schäffer, 1851)	22	1
		Pseudochazara beroe	(Freyer, 1843)	43, 50	2
		Proterebia phegea	(Borkhausen, 1788)	55	1
		Hyponephele lycaon	(Kühn, 1774)	22	1
		Hyponephele lupina	(Costa, 1836)	9, 19, 46, 63, 64	5
		Maniola jurtina	(Linnaeus, 1758)	6, 9, 12, 18, 29, 32, 36, 46	8
		Maniola telmessia	(Zeller, 1847)	6, 9, 15, 18, 19, 23, 27, 29, 30, 32, 37, 44, 64	13

† Provisional identification. Species of the genera *Polyommatus* (except *P. icarus*), *Kretania* and *Pyrgus* cannot be separated reliably on external characters. In *Kretania* and *Pyrgus* this requires genitalic examination; in *Polyommatus*, and especially in the *Agrodiaetus* species group, reliable determination requires karyological or molecular data. These records are excluded from the indicator species analysis and from all inferences about endemism and conservation priority (Section 2.5).

3.3. Species Richness Along the Elevational Gradient

Richness per sampling event averaged 11.7 species (range 1–32) and increased with elevation (Spearman ρ = 0.60, $p < 0.001$; Figure 4a). Because sampling effort differed among belts and among months, this relationship was examined further with generalised linear models assuming negative-binomial errors. Elevation had a strong positive effect when fitted alone (β = +0.430 ± 0.067, z = 6.43, $p < 0.001$). Adding month as a covariate reduced the elevation coefficient by about 30% but left it clearly significant (β = +0.303 ± 0.077, z = 3.92, $p < 0.001$), and month itself did not improve model fit (likelihood-ratio $\chi^2 = 9.01$, df = 8, $p = 0.34$). The positive effect of elevation on richness is therefore not an artefact of the seasonal distribution of sampling, although part of the raw difference is attributable to it.

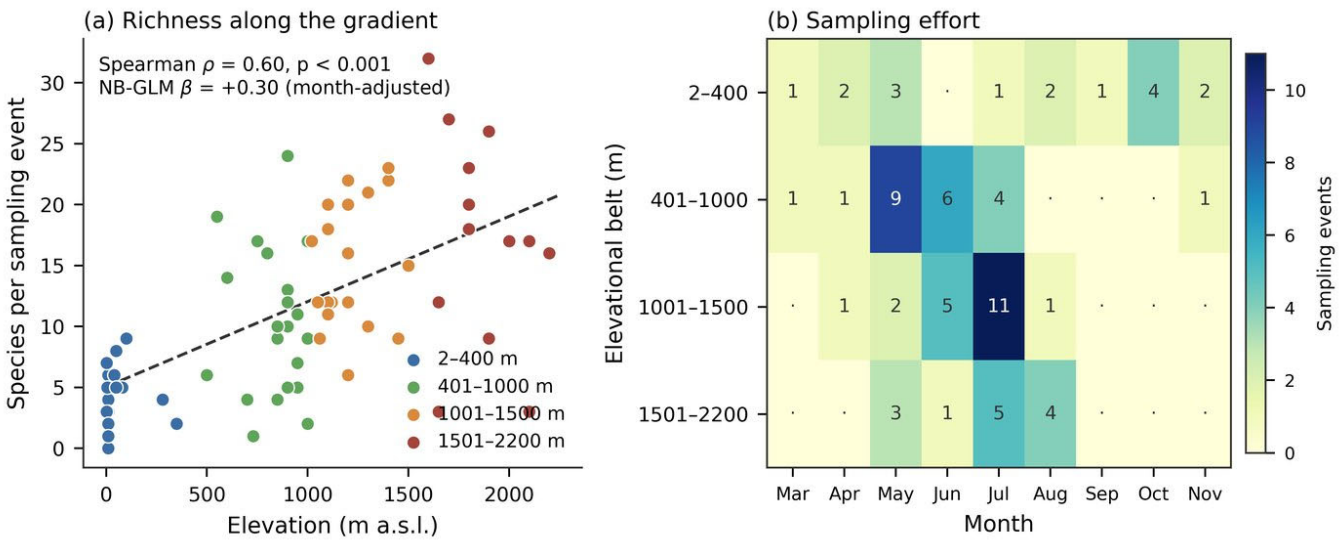

Figure 4. (**a**) Species richness per sampling event against elevation, with points coloured by elevational belt; (**b**) distribution of the 71 sampling events among elevational belts and months. The line in (**a**) is the fitted relationship from the negative-binomial generalised linear model.

Observed richness rose across the four belts, from 24 species in the 2–400 m belt to 78 in each of the 401–1000 and 1001–1500 m belts and 92 in the 1501–2200 m belt. After rarefaction to a common effort of 13 sampling events, the same ordering was retained: 21.8 ± 2.6, 61.9 ± 6.4, 68.3 ± 5.1 and 92.0 species respectively (Figure 3b). Sample coverage was lowest in the 1501–2200 m belt and Chao2 estimates followed the same rank order as the observed values.

3.4. Phenology

Adults were recorded from March to November. The number of species on the wing rose from 8 in March (5.59%) and 34 in April (23.78%) to a maximum of 93 in July (65.03%), with 77 species in May (53.85%), 70 in June (48.95%) and 57 in August (39.86%). Activity fell thereafter, to two species in September (1.40%), ten in October (6.99%) and nine in November (6.29%). Taken together, 130 species (90.91%) were recorded between May and July and 141 (98.60%) between April and August. The low values for March and September reflect the small number of sampling events in those months (Table 2) and should not be read as a phenological result.

3.5. Altitudinal Distribution and Compositional Turnover

Considering the belts separately, 24 species (16.78%) were recorded in the 2–400 m belt, 78 (54.55%) in the 401–1000 m belt, 78 (54.55%) in the 1001–1500 m belt and 92 (64.34%) in the 1501–2200 m belt. Grouping the gradient into two zones, 85 species (59.44%) occurred

in the lower zone (2–1000 m) and 122 (85.31%) in the upper zone (1001–2200 m); the two figures sum to more than the total because many species span both zones. The distribution of each species by month and belt is given in Table 5.

Assemblage composition differed strongly among belts (PERMANOVA, pseudo-F = 4.66, $p < 0.001$, 4999 permutations), and also varied with month (F = 1.98, $p < 0.001$) and district (F = 2.95, $p < 0.001$). Mean Sørensen dissimilarity was lower within belts than between them in every case, and rose with the elevational separation of the belts compared, reaching 0.93 between the lowest and highest belts (Figure 5a). Across all pairs of sampling events, mean total dissimilarity was 0.825, of which the turnover component accounted for 0.732 (88.8%) and the nestedness component for 0.093 (11.2%). Dissimilarity increased with elevational difference (Spearman ρ = 0.35, $p < 0.001$; Figure 5b) and, to a similar degree, with geographic distance (ρ = 0.33, $p < 0.001$).

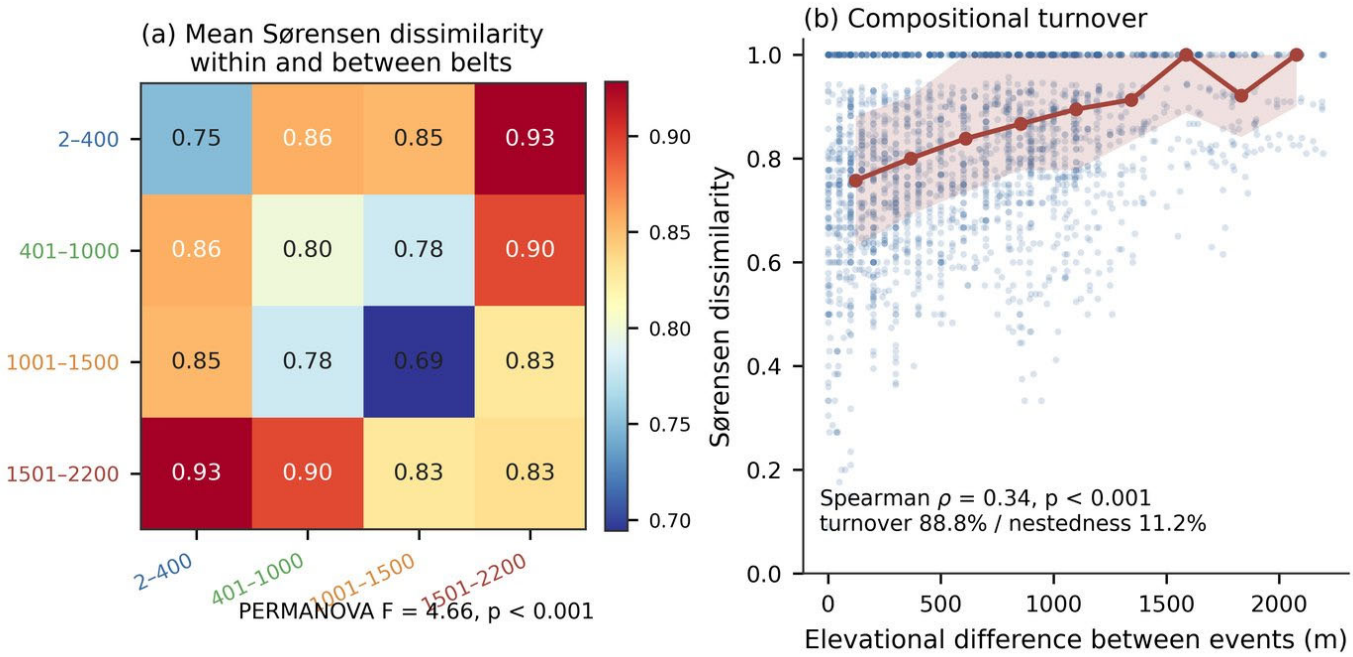

Figure 5. (**a**) Mean Sørensen dissimilarity within and between elevational belts; values on the diagonal are within-belt means. (**b**) Sørensen dissimilarity against the elevational difference between sampling events; the line shows the median of each distance class and the shaded band the interquartile range. Each point represents one pair of sampling events.

The assemblages of the upper belts are therefore not nested subsets of those at lower elevations: the gradient is characterised by the replacement of species rather than by their progressive loss.

3.6. Indicator Species

Indicator species analysis identified taxa significantly associated with individual belts (IndVal > 0.30, $p < 0.05$), provisional records being excluded. *Danaus chrysippus* was the sole indicator of the 2–400 m belt (IndVal = 0.562). Three species characterised the 1001–1500 m belt: *Melanargia larissa* (0.467), *Pontia edusa* (0.375) and *Thymelicus acteon* (0.368). The 1501–2200 m belt had the largest set of indicators, including *Melitaea cinxia* (0.385), *Cupido osiris* (0.308) and *Plebejidea loewii* (0.308). No species reached the criteria for the 401–1000 m belt.

Table 5. Occurrence of each species by month and elevational belt, derived from the sampling events listed in Tables 1 and 4.

Species	March	April	May	June	July	August	September	October	November	2–400	401–1000	1001–1500	1501–2200
Iphiclides podalirius			X		X						X	X	
Papilio machaon		X	X	X							X	X	X
Parnassius mnemosyne			X	X	X						X	X	X
Archon apollinus			X	X							X	X	
Zerynthia cerisy			X	X	X						X	X	
Zerynthia deyrollei			X	X							X	X	
Pelopidas thrax			X			X		X		X			X
Gegenes pumilio			X										X
Ochlodes sylvanus				X							X		
Hesperia comma						X							X
Thymelicus acteon			X	X	X						X	X	
Thymelicus hyrax		X	X	X	X						X	X	X
Thymelicus sylvestris					X	X						X	X
Thymelicus lineola				X	X						X	X	X
Spialia orbifer		X	X	X	X	X					X	X	X
Carcharodus alceae		X	X	X	X	X					X	X	X
Muschampia tessellum					X	X							X
Carcharodus orientalis		X	X		X			X		X	X	X	X
Carcharodus stauderi			X										X
Erynnis tages			X	X	X						X	X	X
Pyrgus sidae †			X										X
Pyrgus serratulae †			X		X								X
Pyrgus armoricanus †					X					X	X	X	X
Pyrgus melotis †		X			X					X	X	X	
Pyrgus cinarae †					X							X	
Leptidea duponcheli		X		X						X		X	
Leptidea sinapis			X	X							X		
Gonepteryx rhamni			X								X		
Gonepteryx farinosa		X	X	X	X						X	X	
Colias alfacariensis		X	X		X	X				X		X	X

Table 5. *Cont.*

Species	March	April	May	June	July	August	September	October	November	2–400	401–1000	1001–1500	1501–2200
Colias aurorina				X		X							X
Colias croceus	X	X	X	X	X	X				X	X	X	X
Aporia crataegi			X	X							X		X
Pontia edusa			X	X	X	X			X	X	X	X	X
Pieris krueperi				X							X		
Pieris brassicae		X	X	X	X	X			X	X	X	X	X
Pieris rapae	X	X	X	X	X	X	X	X	X	X	X	X	X
Pieris mannii				X									X
Pieris ergane		X								X			
Pieris napi	X		X		X						X		X
Euchloe ausonia	X		X							X	X		
Anthocharis cardamines		X	X								X		
Anthocharis gruneri			X	X							X	X	
Anthocharis damone		X		X							X	X	
Lycaena alciphron			X		X	X						X	X
Lycaena thetis			X			X					X		X
Lycaena thersamon			X	X	X							X	
Lycaena candens			X									X	
Lycaena phlaeas		X	X	X	X					X	X	X	X
Lycaena tityrus			X		X							X	X
Tomares nogelii				X									X
Callophrys rubi	X	X									X		
Satyrium ilicis			X	X	X						X	X	X
Satyrium spini			X	X	X						X	X	X
Leptotes pirithous								X		X			
Lampides boeticus		X	X	X	X	X		X		X	X	X	X
Celastrina argiolus	X			X	X						X		X
Pseudophilotes bavius			X		X						X		
Pseudophilotes vicrama			X			X					X		X
Iolana iolas			X								X		

Table 5. *Cont.*

Species	March	April	May	June	July	August	September	October	November	2–400	401–1000	1001–1500	1501–2200
Glaucopsyche alexis		X			X						X	X	
Zizeeria karsandra								X	X	X	X		
Cupido osiris			X	X	X	X							X
Freyeria trochylus			X		X						X	X	
Plebejus argus					X	X							X
Plebejus idas					X								X
Plebejus hyacinthus			X	X	X						X	X	
Plebejidea loewii					X	X							X
Eumedonia eumedon					X								X
Kretania eurypilos †					X	X							X
Kretania sephirus †			X	X	X	X					X	X	X
Kretania alcedo †				X								X	
Kretania pylaon †					X								X
Cyaniris bellis		X	X	X							X	X	
Cyaniris semiargus		X	X	X							X	X	X
Aricia anteros		X	X	X							X		
Aricia artaxerxes			X								X		
Aricia agestis		X	X	X	X	X				X	X	X	X
Neolysandra coelestina			X										X
Lysandra bellargus		X	X	X	X	X					X	X	X
Polyommatus thersites †		X	X	X	X	X					X	X	X
Polyommatus daphnis †			X		X	X						X	X
Polyommatus amandus †			X	X	X							X	X
Polyommatus dorylas †					X							X	
Polyommatus icarus	X	X	X	X	X	X		X		X	X	X	X
Polyommatus actis †					X	X							X
Polyommatus admetus †					X	X							X
Polyommatus ripartii †					X	X							X

Table 5. *Cont.*

Species	March	April	May	June	July	August	September	October	November	2–400	401–1000	1001–1500	1501–2200
Polyommatus sertavulensis †					X	X							X
Polyommatus iphigenia †					X	X							X
Polyommatus hopfferi †					X	X							X
Polyommatus ossmar †			X		X	X						X	X
Polyommatus phyllis †						X							X
Polyommatus carmon †					X							X	
Polyommatus eroides †				X	X							X	
Polyommatus poseidon †					X								X
Polyommatus wagneri †						X							X
Polyommatus syriacus †			X	X							X	X	X
Polyommatus cornelia †			X		X	X						X	X
Limenitis reducta			X	X	X						X	X	
Issoria lathonia			X		X	X						X	X
Argynnis paphia				X	X	X					X	X	X
Argynnis pandora				X	X	X					X	X	X
Speyeria aglaja					X	X						X	X
Fabriciana niobe			X		X							X	X
Fabriciana adippe					X							X	
Vanessa cardui	X	X	X	X	X	X		X	X	X	X	X	X
Vanessa atalanta		X	X	X	X			X	X	X	X	X	X
Aglais urticae			X										X
Polygonia c-album				X							X		
Nymphalis polychloros		X		X							X		
Melitaea trivia		X		X	X	X				X	X	X	X
Melitaea didyma			X	X	X	X					X	X	X
Melitaea phoebe			X	X	X						X	X	
Melitaea cinxia			X	X	X								X
Melitaea punica			X		X						X		X

Table 5. *Cont.*

Species	March	April	May	June	July	August	September	October	November	2–400	401–1000	1001–1500	1501–2200
Libythea celtis		X	X							X	X		
Danaus chrysippus						X	X	X	X	X			
Coenonympha pamphilus		X	X	X	X	X					X	X	X
Coenonympha leander					X								X
Kirinia roxelana				X	X						X	X	X
Pararge aegeria			X	X	X				X		X	X	
Lasiommata maera				X	X	X					X	X	X
Lasiommata megera				X					X		X	X	
Melanargia larissa		X	X	X	X	X					X	X	X
Melanargia syriaca					X	X						X	X
Melanargia titea				X							X		
Hipparchia syriaca				X	X						X	X	
Hipparchia statilinus					X	X							X
Hipparchia mersina				X	X						X		
Brintesia circe			X	X	X						X	X	
Satyrus favonius						X							X
Satyrus ferula						X							X
Chazara briseis					X	X						X	X
Chazara persephone					X	X							X
Pseudochazara anthelea					X								X
Pseudochazara mniszechii						X							X
Pseudochazara beroe					X	X							X
Proterebia phegea		X								X			
Hyponephele lycaon						X							X
Hyponephele lupina				X	X							X	X
Maniola jurtina			X	X	X						X	X	
Maniola telmessia			X	X	X	X					X	X	

† As in Table 4. X indicates that the species was recorded in that month or elevational belt.

3.7. Protected Areas

Thirteen sampling events fell within Wildlife Development Areas, all between 1000 and 2100 m. Rarefied to thirteen sampling events, the protected localities yielded 88.0 species and unprotected localities above 1000 m 86.0 ± 6.8, and mean richness per event did not differ significantly (13.5 inside against 16.6 outside; Mann–Whitney U = 114, p = 0.25). Sample coverage inside the protected areas was 75.5%, against 96.2% outside, and observed richness corresponded to 61.9% of the Chao2 estimate inside against 91.2% outside. Sixteen species were recorded only inside the protected areas, four of them provisional identifications (Section 2.5).

4. Discussion

4.1. A Near-Complete Inventory for a Previously Unsurveyed Gradient

The 143 species recorded here represent the first systematic survey of butterflies across the full elevational range of the southern Bolkar Mountains and the adjoining Çukurova plain. The value of the dataset rests less on the number of species than on the evidence that the inventory approaches saturation: sample coverage reached 96.7%, and observed richness corresponded to 90.6% of the Chao2 estimate, implying that some 15 species remain to be found. Faunistic lists are frequently published without any assessment of their own completeness, which leaves the reader unable to judge whether an absence is biological or methodological. Here the residual gap is quantified, and the parts of the gradient responsible for it can be identified (Section 4.4).

This is the highest total so far reported from a single survey area in the Turkish central Taurus, exceeding the 131 species of the Göksu valley in Mut [13] and the 125 species of the western Taurus at Anamur and Bozyazı [14], both of which used comparable methods over a similar number of surveys (Table 6). Two features of the present dataset probably account for the difference: its elevational span of 2198 m is the widest of the five studies, and it is the only one that reaches both the coastal plain and the subalpine belt; and sampling extended from March to November, whereas the Göksu valley survey was confined to April–August and the Darboğaz survey to July and August.

Table 6. Butterfly inventories from comparable areas of southern Anatolia, arranged by observed species richness.

Study Area (Source)	Period/Months	Surveys	Species	Elevation (m)	Span (m)	Species per Survey
S Bolkar Mts & adjacent Çukurova plain, Mersin (present study)	2016–2024, March–November	71	143	2–2200	2198	2.0
Göksu valley, Mut, Mersin [12]	2007–2009, April–August	58	131	100–1750	1650	2.3
W Taurus (Anamur, Bozyazı), Mersin [13]	2004–2009, April–October	43	125	50–1690	1640	2.9
Amanos Mts, İslahiye, Gaziantep [14]	2006–2007, March–October	55	76	500–1500	1000	1.4
Darboğaz, Bolkar Mts, Niğde [15] *	2008–2009, July–August	9	63	1450–2325	875	7.0

* Butterfly component only; that study also reported 105 species of nocturnal Lepidoptera. Generic totals are not compared, because the earlier studies treated *Polyommatus* and *Argynnis* in the broad sense whereas the present study follows Wiemers et al. [9]. None of the earlier studies reported an estimate of inventory completeness, so the comparison is of observed richness alone.

The comparison also shows why richness alone is a poor basis for judging a fauna. Richness per survey was highest at Darboğaz, at seven species per survey against 1.4 to 2.9 elsewhere, simply because that study comprised nine surveys concentrated in the peak flight period at high elevation; its total of 63 butterfly species is correspondingly the lowest. Because none of these studies reported an estimate of asymptotic richness or sample coverage, it is not possible to say whether the differences reflect the faunas themselves or the completeness of the inventories.

Family-level composition was broadly consistent across the central Taurus studies. Lycaenidae and Nymphalidae together accounted for 69.3% of species in the present study, 72.6% in the Göksu valley and 71.2% in the western Taurus. The Amanos fauna departs from this pattern, with Lycaenidae reduced to 23.7%, which is consistent with its lower maximum elevation [15]. Generic totals are not compared, because the earlier studies treated Polyommatus and Argynnis in the broad sense whereas the present study follows Wiemers et al. [9].

4.2. Richness Increases with Elevation, but the Pattern Differs from That Usually Reported

Species richness per sampling event rose with elevation, and this pattern held after rarefaction to equal effort and after adjusting for month of sampling. The increase was monotonic across all four belts, with the highest richness in the 1501–2200 m belt.

This differs from the pattern most commonly reported for butterflies on European and Mediterranean mountains, where richness typically peaks at low to intermediate elevations and declines towards the summit [1,2,31]. Two features of the present gradient plausibly account for the difference.

First, the transect may not extend high enough to capture the decline. In the French Alps richness rises to a maximum at about 700 m, remains near-constant to 1900 m and falls sharply above it [2], but the treeline in the central Taurus lies considerably higher, and the highest locality sampled here (2200 m) is at or just below it. The Bolkar massif culminates at 3524 m, so the subalpine and alpine belts above the present transect remain unsurveyed; the monotonic increase reported here therefore describes the lower part of the available gradient rather than the whole of it.

Second, the lowest belt is not a natural baseline. The 2–400 m belt lies almost entirely under irrigated cultivation and urban expansion on the Çukurova plain, and its low richness is consistent with the strong negative effect of arable land and urbanisation on lowland butterfly richness documented elsewhere [2,32]. Mid- and high-elevation belts in this area, by contrast, retain semi-natural grassland, forest clearings and rocky steppe, offering a wider range of larval host plants and nectar sources. The pattern documented here is therefore likely to reflect the combined action of Mediterranean summer drought at low elevations and land-use intensity, rather than elevation alone; the two cannot be separated with the present data.

4.3. The Gradient Is Structured by Species Replacement, Not by Species Loss

The strongest compositional result is the dominance of turnover in the partitioning of beta diversity: of a mean Sørensen dissimilarity of 0.825, the turnover component accounted for 88.8% and the nestedness component for only 11.2%. Mean dissimilarity was lower within belts than between them in every comparison, and rose with elevational separation, reaching 0.93 between the lowest and highest belts. Composition differed significantly among belts (PERMANOVA, $F = 4.66$, $p < 0.001$). Excluding all provisional identifications changed these values only marginally (total 0.814, turnover 88.5%; richness–elevation $\rho = 0.52$, $p < 0.001$), so no conclusion drawn here depends on the taxonomically difficult groups.

The high-elevation assemblages are therefore not impoverished subsets of the lowland fauna: they are compositionally distinct. This has a direct consequence for conservation. Where beta diversity is dominated by nestedness, protecting the richest site conserves most of the regional fauna; where it is dominated by turnover, as here, no single elevational belt can substitute for another, and the conservation unit is the gradient as a whole.

A caveat must be stated plainly. Dissimilarity increased with elevational difference ($\rho = 0.35$) and with geographic distance to a very similar degree ($\rho = 0.33$), because the highest localities lie in the west of the study area and the lowest in the east (Figure 1). The design does not allow the effect of elevation to be separated from that of geographic distance, and the turnover documented here should be attributed to the combined gradient rather than to elevation alone.

4.4. The Protected Areas Are the Least Known Part of the Gradient

Two results follow from the comparison of protected and unprotected localities. First, and contrary to what might be expected, richness inside the protected areas did not exceed that of unprotected localities at comparable elevations: rarefied to thirteen sampling events, the protected localities yielded 88.0 species and the unprotected localities above 1000 m 86.0 $\pm$ 6.8, and mean richness per event did not differ significantly (13.5 against 16.6; Mann–Whitney U = 114, $p = 0.25$). The existing reserve network is therefore neither richer nor poorer than comparable unprotected land: it is not preferentially located in the most species-rich part of the gradient.

Second, the protected areas are markedly the least completely surveyed part of the study area. Sample coverage inside them was 75.5%, against 96.2% outside, and observed richness corresponded to 61.9% of the Chao2 estimate inside against 91.2% outside—that is, roughly three-fifths of the expected fauna has been recorded there against nine-tenths elsewhere. Sixteen species were found only inside the protected areas, from just thirteen sampling events, although four of these are provisional identifications (Section 2.5).

These figures apply to the sampled part of the reserves: thirteen sampling events within two areas totalling more than 36,000 ha, one of which extends into a district where no sampling was carried out. The low coverage recorded inside the protected areas is therefore unsurprising, and it is precisely why targeted survey work there would be productive. Taken together, these results indicate that the reserves are neither demonstrably richer nor adequately inventoried.

These findings are not peculiar to the study area. A recent global assessment concluded that roughly three-quarters of insect species are inadequately represented within existing protected area systems, and that conservation frameworks rarely take species range dynamics into account when protected areas are delineated [6]. The reserves examined here are consistent with that picture: they occupy only the upper part of a gradient whose value, as shown above, lies in its full extent.

4.5. Comparison with the Historical Fauna

Hesselbarth et al. [19], the standard work on the butterflies of Türkiye, lists 126 species from localities within the present study area for which a definite locality is given, drawing on records accumulated from the nineteenth century onwards. Comparison with that compilation is possible only after nomenclature is standardised: seventeen taxa differ from current usage in generic placement or spelling and would otherwise appear, wrongly, as absent from the present survey. Most of these are straightforward generic recombinations of a kind that has occurred repeatedly in Papilionoidea and that carries no implication for species identity. One case is of a different order and deserves separate mention: records published as *Plebeius pylaon* refer here to *Kretania sephirus*, following the division of the *pylaon* complex into several species,

so that the historical name denotes a different taxonomic entity rather than merely a different generic combination.

Of the 126 historical species, 104 (82.5%) were refound here, and 39 of the 143 species recorded in the present survey are not listed for the study area by Hesselbarth et al. Together the two sources give 165 species for the area (Table 7). The present survey therefore accounts for 86.7% of the total known fauna and adds 23.6% to it.

Table 7. Butterfly species recorded from the study area by Hesselbarth et al. [19] and in the present survey.

	Species	% of the 165 Species Known from the Area
Recorded by Hesselbarth et al.	126	76.4
Recorded in the present survey	143	86.7
Recorded by both	104	63.0
Recorded only in the present survey	39	23.6
Recorded only by Hesselbarth et al.	22	13.3
Total known from the study area	165	100.0

Twenty-two historical species were not refound (Table 8). Setting the historical localities against the months in which the present survey visited them shows that most of these records could not have been confirmed on the present sampling schedule. The Gülek–Karboğazı area, from which thirteen of the twenty-two were reported, was sampled only in August 2017, and Gözne, from which a further six were reported, only in late March 2024. Species flying outside those windows were therefore undetectable at the relevant localities: *Papilio alexanor*, recorded historically at Gözne, flies from May to July and could not have been found on a single visit in March. For only two species—*Carcharodus lavatherae* and *Tarucus balkanicus*—do the present data cover seven months at the corresponding localities, and only for these does failure to refind carry any weight as evidence of change.

Table 8. Species listed for the study area by Hesselbarth et al. [19] but not recorded in the present survey, with the months in which the corresponding localities were sampled here.

Species	Historical Locality	Elevation (m)	Months Sampled Here
Brenthis daphne	Karboğazı	1600–1900	August
Carcharodus lavatherae	Yeniköy	1000–1100	April, June, July, August, September, October, November
Charaxes jasius	Gözne, Gülek	not stated	March, August
Cigaritis cilissa	Tarsus–Gülek	not stated	March, August
Euchloe penia	Çamlıyayla	1800	May, June, July, August
Favonius quercus	Yeniköy, Gözne	1000–1100	March, July
Glaucopsyche iolas	Gözne, Gülek	1000–1100	March, August
Gonepteryx cleopatra	Ulaş, Kulak	20–350	August
Hipparchia aristaeus	Arslanköy, Gülek, Elmalı Boğazı	1300–1500	July, August
Hipparchia fatua	S Yeniköy	800	—
Hipparchia pellucida	Gülek	1350	August
Melitaea collina	Gülek	1000	August
Muschampia proteides	Gülek	not stated	August
Nymphalis antiopa	Gülek	not stated	August

Table 8. *Cont.*

Species	Historical Locality	Elevation (m)	Months Sampled Here
Nymphalis xanthomelas	Gülek, Taurus N Tarsus	not stated	August
Papilio alexanor	Gözne	1000	March
Polygonia egea	Belçınar, Gülek, Elmalı Boğazı	750–1400	June, August
Polyommatus menalcas	Elmalı Boğazı	1350	August
Pseudochazara lydia	Elmalı Boğazı, Gülek	1000–1350	August
Pseudochazara mamurra	Karboğazı	1200–2000	August
Tarucus balkanicus	Gözne, Tarsus, Gülek	1000–1100	March, April, June, August, September, October, November
Turanana endymion	Arslanköy, Gülek	1650	July, August

Historical localities and elevations are as given by Hesselbarth et al. [19]; "not stated" indicates that the source gives a locality but no elevation. Months are those in which the present survey sampled the corresponding localities of Table 1; a dash indicates that no locality of the present survey corresponds closely to the historical one.

This comparison therefore says less about the fauna than about the survey. It identifies a specific and remediable gap: the Gülek–Karboğazı transect, which spans 1200–2200 m and holds the richest single group of localities in the dataset, has been sampled only at the end of the flight season, and Gözne only at its beginning. Extending sampling at these two areas to May, June and July would test most of the twenty-two unconfirmed records directly, and would also address the shortfall in coverage identified for the uppermost elevational belt (Section 3.1). Whether any of the historical species has genuinely been lost from the area cannot be determined from presence data collected in a single period, and no such claim is made here.

4.6. Limitations

Identification. Genitalic dissection was not undertaken, and no karyological or molecular work was carried out. Twenty-seven of the 143 species are reported as provisional (Section 2.5) and are excluded from the indicator species analysis and from any inference about endemism or conservation priority. Confirming them, which in *Polyommatus* will require karyotyping or molecular markers rather than genitalic preparations alone, is a priority for further work and would allow the endemic element of this fauna to be assessed, which the present data do not permit.

Sampling design. Survey duration was not standardised, so records are treated as species incidences and no abundance-based diversity measure was calculated. Effort was unevenly distributed among months and belts (Table 2): September is represented by a single event and March by two. The uppermost belt has the fewest sampling events (13), which both defines the rarefaction reference and leaves that belt with the largest estimated shortfall in species. No fieldwork was carried out in 2019–2021.

Phenological compression at high elevation. The flight season contracts with elevation, so that spring species appear later and late-season species earlier, and a greater part of the fauna is compressed into a short summer window. Where survey effort is concentrated in that window, a larger share of the high-elevation fauna is recorded per visit than at low elevations, where the same fauna is spread across a longer season. Beck et al. [33] showed for Alpine macro-moths that the altitude–diversity relationship itself changes with season, diversity declining with elevation in spring and autumn but peaking at mid-elevations in summer. In the present dataset the two upper belts were surveyed predominantly in summer (85.0% and 76.9% of their sampling events) and the lowest belt predominantly

in spring and autumn (81.3% combined). This distribution follows the phenology of the belts concerned, since butterfly activity in the Mediterranean lowland peaks in spring and again in autumn and falls during the summer drought, whereas the subalpine belt is both accessible and active only in summer. Sampling month is not correlated with elevation across the 71 events (Spearman $\rho = -0.016$, $p = 0.89$) and shows no monotonic trend among belts (mean month 7.5, 5.8, 6.5 and 6.8 from the lowest belt to the highest). Month did not improve the fit of the richness model and the elevation coefficient remained significant when month was included as a covariate (Section 3.2). The elevational increase in richness reported here is therefore unlikely to be an artefact of the seasonal distribution of sampling, but the two effects cannot be separated completely with the present design; a scheme in which every belt is sampled in every month would be required to do so.

Boundary assignment. Because each sampling event covered an area rather than a point, and because three of the thirteen protected-area localities lie close to a reserve boundary, the division of localities into protected and unprotected is approximate at the margins; the comparison in Section 4.4 should be read accordingly.

Scope. Only Papilionoidea were surveyed. Other diurnal Lepidoptera, including Zygaenidae, Sesiidae and day-flying Erebidae and Geometridae, were not targeted; the diurnal Lepidoptera fauna of the area is consequently richer than the figures given above.

5. Conclusions

This study provides the first quantitative account of butterfly richness and compositional turnover along the 2–2200 m gradient of the southern Bolkar Mountains and the adjacent Çukurova plain. The inventory is close to complete at the scale of the whole gradient, richness increases with elevation after accounting for sampling effort and season, and the assemblage is structured overwhelmingly by species replacement rather than by nested species loss. The practical implication is that conservation value in this landscape is distributed along the entire elevational sequence and cannot be secured by protecting any single belt. The existing protected areas, although they hold species found nowhere else in the dataset, are neither demonstrably richer than comparable unprotected land nor adequately surveyed, and closing that gap is the most immediate priority.

Set against the historical record, the survey refound 104 of the 126 species compiled by Hesselbarth et al. [19] and added 39, leaving 22 unconfirmed; almost all of the latter come from localities that the present survey visited in a single month, so the comparison points to a sampling gap rather than to faunal change. The dataset also identifies where further effort would be most productive: the subalpine belt above 1500 m, the shoulder seasons of March and September, the Gülek–Karboğazı and Gözne areas in the May–July period, and the interior of the reserves themselves. These priorities coincide with those recently identified at the global scale, where elevational gradients, endemism centres and regions poorly represented in the existing evidence base have been singled out as the areas in which butterfly monitoring most needs to be expanded [6]. Elevational range shifts have so far been documented for fewer than 400 butterfly species worldwide, and from only eighteen countries; a quantified baseline for a continuous Anatolian gradient contributes directly to closing that gap.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/d18090550/s1, File S1. Species occurrence data and sampling event metadata. File S2. Analysis code.

Funding: This research was supported in part by the Scientific Research Projects Unit of Mersin University (Project No. 2016-1-AP3-1419).

Institutional Review Board Statement: Not applicable. Collecting permits are not required for invertebrates in Türkiye (Section 2.7).

Data Availability Statement: The species-by-event incidence matrix and the analysis code are provided as Supplementary Materials Files S1 and S2.

Acknowledgments: The author thanks the staff of the Tarsus Forest Enterprise Directorate for their assistance during fieldwork in the Cehennem Deresi and Kadıncık Vadisi Wildlife Development Areas, and for a continuing collaboration on the identification of Lepidoptera material; and Serdar Sönmez for preparing Figure 1.

Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

TLA Three-letter acronym

References

1. McCain, C.M.; Grytnes, J.-A. Elevational gradients in species richness. In *Encyclopedia of Life Sciences (eLS)*; John Wiley & Sons: Chichester, UK, 2010.
2. Gallou, A.; Baillet, Y.; Ficetola, G.F.; Després, L. Elevational gradient and human effects on butterfly species richness in the French Alps. *Ecol. Evol.* **2017**, *7*, 3672–3681. [CrossRef]
3. Warren, M.S.; Maes, D.; van Swaay, C.A.M.; Goffart, P.; Van Dyck, H.; Bourn, N.A.D.; Wynhoff, I.; Hoare, D.; Ellis, S. The decline of butterflies in Europe: Problems, significance, and possible solutions. *Proc. Natl. Acad. Sci. USA* **2021**, *118*, e2002551117. [CrossRef]
4. van Swaay, C.; Warren, M.; Ellis, S.; Clay, J.; Bellotto, V.; Allen, D.J.; Trottet, A. *Measuring the Pulse of European Biodiversity: European Red List of Butterflies*; European Commission: Brussels, Belgium, 2025.
5. Wepprich, T.; Adrion, J.R.; Ries, L.; Wiedmann, J.; Haddad, N.M. Butterfly abundance declines over 20 years of systematic monitoring in Ohio, USA. *PLoS ONE* **2019**, *14*, e0216270. [CrossRef]
6. Chowdhury, S.; Aich, U.; Antão, L.H.; Pinkert, S.; Akite, P.; Almeida, G.S.S.; Amano, T.; Ambrus, A.; Badon, J.A.T.; Baek, S.-Y.; et al. Extensive climate-induced range shifts in butterflies across the globe. *Nat. Ecol. Evol.* **2026**. [CrossRef]
7. Wilson, R.J.; Gutiérrez, D.; Gutiérrez, J.; Martínez, D.; Agudo, R.; Monserrat, V.J. Changes to the elevational limits and extent of species ranges associated with climate change. *Ecol. Lett.* **2005**, *8*, 1138–1146. [CrossRef]
8. Karaçetin, E.; Welch, H.J. *Türkiye'deki Kelebeklerin Kırmızı Kitabı*; Doğa Koruma Merkezi: Ankara, Türkiye, 2011.
9. Wiemers, M.; Balletto, E.; Dincă, V.; Fric, Z.F.; Lamas, G.; Lukhtanov, V.; Munguira, M.L.; van Swaay, C.A.M.; Vila, R.; Vliegenthart, A.; et al. An updated checklist of the European Butterflies (Lepidoptera, Papilionoidea). *ZooKeys* **2018**, *811*, 9–45. [CrossRef]
10. Vila, R.; Lukhtanov, V.A.; Talavera, G.; Gil-T., F.; Pierce, N.E. How common are dot-like distributions? Taxonomical oversplitting in western European *Agrodiaetus* (Lepidoptera: Lycaenidae) revealed by chromosomal and molecular markers. *Biol. J. Linn. Soc.* **2010**, *101*, 130–154. [CrossRef]
11. Vishnevskaya, M.S.; Saifitdinova, A.F.; Lukhtanov, V.A. Karyosystematics and molecular taxonomy of the anomalous blue butterflies (Lepidoptera, Lycaenidae) from the Balkan Peninsula. *Comp. Cytogenet.* **2016**, *10*, 1–85. [CrossRef]
12. Hüseyinoğlu, Y. A faunistic study on Papilionoidea and Hesperioidea (Lepidoptera) of Murat Mountain in Banaz, Uşak Province, Turkey. *Pak. J. Zool.* **2013**, *45*, 437–445.
13. Hüseyinoğlu, Y. Faunistic study on Papilionoidea and Hesperioidea (Lepidoptera) of Göksu Valley in Mut, southern Turkey. *Pak. J. Zool.* **2013**, *45*, 1291–1297.
14. Hüseyinoğlu, Y. A faunistic study of Papilionoidea (Lepidoptera) of the Western Taurus Mountains, Turkey. *J. Kans. Entomol. Soc.* **2014**, *87*, 74–83. [CrossRef]
15. Durmaz, M.; Hüseyinoğlu, Y. Faunistic study of the Papilionoidea and Hesperioidea (Lepidoptera) from the Amanos Mountains in İslahiye, Turkey. *J. Kans. Entomol. Soc.* **2016**, *89*, 100–113. [CrossRef]
16. Hüseyinoğlu, Y.; Atay, E. A faunistic study of diurnal and nocturnal Lepidoptera in Darboğaz, Bolkar Mountains (Niğde, Turkey). *J. Kans. Entomol. Soc.* **2017**, *90*, 44–53. [CrossRef]
17. Koçak, A.Ö.; Kemal, M. Revised checklist of the Lepidoptera of Turkey. *Priamus Suppl.* **2009**, *17*, 1–253. [CrossRef]
18. Atalay, İ. *Vegetation Geography of Turkey*; Ege Üniversitesi Basımevi: Bornova, Türkiye, 1994.
19. Hesselbarth, G.; van Oorschot, H.; Wagener, S. *Die Tagfalter der Türkei, 3 Bände*; Selbstverlag Sigbert Wagener: Bocholt, Germany, 1995.
20. Hofmann, H.; Marktanner, T. *Butterflies and Moths of Britain and Europe*; Collins Nature Guides; HarperCollins: London, UK, 1995.

21. van Nieukerken, E.J.; Kaila, L.; Kitching, I.J.; Kristensen, N.P.; Lees, D.C.; Minet, J.; Mitter, C.; Mutanen, M.; Regier, J.C.; Simonsen, T.J.; et al. Order Lepidoptera Linnaeus, 1758. *Zootaxa* **2011**, *3148*, 212–221. [CrossRef]
22. Heikkilä, M.; Kaila, L.; Mutanen, M.; Peña, C.; Wahlberg, N. Cretaceous origin and repeated Tertiary diversification of the redefined butterflies. *Proc. R. Soc. B* **2012**, *279*, 1093–1099. [CrossRef]
23. Lepidoptera Mundi. Available online: http://www.lepidoptera.eu (accessed on 15 August 2026).
24. Lepiforum e.V. Available online: http://www.lepiforum.org (accessed on 15 August 2026).
25. Colwell, R.K.; Chao, A.; Gotelli, N.J.; Lin, S.-Y.; Mao, C.X.; Chazdon, R.L.; Longino, J.T. Models and estimators linking individual-based and sample-based rarefaction, extrapolation and comparison of assemblages. *J. Plant Ecol.* **2012**, *5*, 3–21. [CrossRef]
26. Chao, A. Estimating the population size for capture–recapture data with unequal catchability. *Biometrics* **1987**, *43*, 783–791. [CrossRef]
27. Chao, A.; Jost, L. Coverage-based rarefaction and extrapolation: Standardizing samples by completeness rather than size. *Ecology* **2012**, *93*, 2533–2547. [CrossRef]
28. Baselga, A. Partitioning the turnover and nestedness components of beta diversity. *Glob. Ecol. Biogeogr.* **2010**, *19*, 134–143. [CrossRef]
29. Anderson, M.J. A new method for non-parametric multivariate analysis of variance. *Austral Ecol.* **2001**, *26*, 32–46. [CrossRef]
30. Dufrêne, M.; Legendre, P. Species assemblages and indicator species: The need for a flexible asymmetrical approach. *Ecol. Monogr.* **1997**, *67*, 345–366. [CrossRef]
31. Wilson, R.J.; Gutiérrez, D.; Gutiérrez, J.; Monserrat, V.J. An elevational shift in butterfly species richness and composition accompanying recent climate change. *Glob. Change Biol.* **2007**, *13*, 1873–1887. [CrossRef]
32. Forister, M.L.; McCall, A.C.; Sanders, N.J.; Fordyce, J.A.; Thorne, J.H.; O'Brien, J.; Waetjen, D.P.; Shapiro, A.M. Compounded effects of climate change and habitat alteration shift patterns of butterfly diversity. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 2088–2092. [CrossRef]
33. Beck, J.; Altermatt, F.; Hagmann, R.; Lang, S. Seasonality in the altitude–diversity pattern of Alpine moths. *Basic Appl. Ecol.* **2010**, *11*, 714–722. [CrossRef]

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