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ORIGINAL PAPER

Integrating national Red Lists for prioritising conservation actions for European butterflies

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Abstract
Red Lists are very valuable tools in nature conservation at global, continental and (sub-) national scales. In an attempt to prioritise conservation actions for European butterflies, we compiled a database with species lists and Red Lists of all European countries, including the Macaronesian archipelagos (Azores, Madeira and Canary Islands). In total, we compiled national species lists for 42 countries and national Red Lists for 34 of these. The most species-rich countries in Europe are Italy, Russia and France with more than 250 species each. Endemic species are mainly found on the Macaronesian archipelagos and on the Mediterranean islands. By attributing numerical values proportionate to the threat statuses in the different national Red List categories, we calculated a mean Red List value for every country (cRLV) and a weighted Red List value for every species (wsRLV) using the square root of the country's area as a weighting factor. Countries with the highest cRLV were industrialised (NW) European countries such as the Netherlands, Belgium, the Czech Republic and Denmark, whereas large Mediterranean countries such as Spain and Italy had the lowest cRLV. Species for which a Red List assessment was available in at least two European countries and with a relatively high wsRLV (≥ 50) are *Colias myrmidone, Pseudochazara orestes, Tomares nogelii, Colias chrysotheme* and *Coenonympha oedippus*. We compared these wsRLVs with the species statuses on the European Red List to identify possible mismatches. We discuss how this complementary method can help to prioritise butterfly conservation on the continental and/or the (sub-)national scale.

Keywords Policy · Management · Threatened species · Habitats directive · IUCN · Biogeography · Lepidoptera

Introduction

Red Lists provide information on the extinction risk of species in a given region (IUCN 2013) and have become well-established tools in nature conservation (e.g. Keller and Bollmann 2004; Butchart et al. 2005; Rodrigues et al. 2006; Fitzpatrick et al. 2007). Regional IUCN criteria (Gärdenfors et al. 2001; IUCN 2012) are increasingly used at the (sub-)

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national level, although some countries use specific regional/national criteria or local expert judgements to produce Red Lists. There are, however, numerous approaches for compiling Red Lists. Most Red List assessments in Europe or other areas of biodiversity importance (e.g. the Mediterranean region—Numa et al. 2016) use the IUCN Red List categories and criteria (e.g. amphibians—Temple and Cox 2009; vascular plants—Bilz et al. 2011; Orthoptera—Hochkirch et al. 2016). The use of IUCN criteria makes it possible to compare Red Lists more easily among countries but also among taxonomic groups and habitat types (Juslén et al. 2016). Although criticized by some, Red Lists are often used to prioritise conservation actions for threatened species (Possingham et al. 2002), with species in the highest Red List category usually receiving higher resource allocation for conservation (but see Neeson et al. 2018). We explore using national and continental Red Lists in relation to existing legislation such as the European Habitats Directive (Council Directive 92/43/EEC) and endemism as complementary tools to classify species of conservation importance. An integrated comparison of national Red Lists and the European Red List makes it possible to identify species that show a mismatch between both scales (Brito et al. 2010).

The IUCN uses five criteria to classify species in Red List categories (IUCN 2001): (a) population size reduction, (b) restricted geographic range size, (c) small population size and decline, (d) very small population or restricted distribution and (e) quantitative analysis of extinction risk. The application of these criteria results in classification of a species within 11 possible IUCN categories at the regional level (Gärdenfors et al. 2001). Regional IUCN criteria use the same quantitative criteria as those applied to global Red Lists with an additional criterion for downgrading the Red List category when a rescue effect is possible from neighbouring countries or regions or upgrading when the neighbouring populations are a sink (Gärdenfors et al. 2001). During a Red List assessment, species are assessed against all possible IUCN criteria and the Red List category resulting in the highest level of extinction risk being assigned to the species.

To test the difference between a supra-national integration of Red Lists of European countries and the European Red List, we used butterflies (Lepidoptera: Papilionoidea) as a model group. This is because they are among the best studied invertebrates in Europe (Settele et al. 2009). Despite large differences in data availability on distribution and/or trend data (Maes et al. 2015), many countries have compiled national or even regional Red Lists for this taxonomic group. Also at the European level, the IUCN Red List for butterflies is available (van Swaay et al. 2010). Especially for invertebrates, the applicability of IUCN criteria for national or regional Red Lists has been criticised by some as inappropriate (Cardoso et al. 2011; van Swaay et al. 2011), but defended by others (Collen and Böhm 2012). Here, we propose an alternative method to overcome the differences in Red List approaches among countries and to complement the present European IUCN Red List (van Swaay et al. 2010).

In this paper, we first compiled the most up to date information for all the European countries into an open access database published on the global biodiversity information facility (GBIF) platform using the most recent information on taxonomy and distribution. Second, we gathered the most recent national Red Lists from as many European countries as possible. With these data, we subsequently calculated a weighted species Red List Value (wsRLV) for all European butterflies by attributing numerical values proportionate to the threat statuses in the different national Red List categories in the different European countries. We compared this wsRLV with the Red List status in the European Red List of butterflies (van Swaay et al. 2010) to determine possible mismatches between both approaches (i.e. are we overlooking species on a European scale, that are threatened in a large part of Europe?). We discuss how our approach could additionally rank priorities for conservation actions for butterflies in Europe, complementary to the already existing ones such as the European Habitats Directive and the European Red List.

Materials and methods

For the purposes of the present work, we used the same delineation for Europe as in the Red List of European butterflies (van Swaay et al. 2010—Fig. 1) and Fauna Europaea (https://fauna-eu.org/data-handling): European mainland (Western Palearctic), including the Macaronesian archipelagos (excluding Cape Verde Islands), Cyprus, Franz Josef Land and Novaya Zemlya, but excluding the Western Kazakhstan. The European part of Russia (west of the Ural Mountains) and the Crimea are also included, but in contrast to Fauna Europaea European Turkey is excluded. This comprises 42 countries (excluding small countries such as Monaco, San Marino and Vatican City—Table 1). The Macaronesian archipelagos (Azores, Madeira and Canary Islands), which administratively belong to European countries (Portugal or Spain) were treated as separate "countries" because of their distinct biogeographical positions.

For each of the 42 European countries, national species lists were compiled using the most recent literature and/or websites. These lists were checked by national experts (all co-authors) of the Butterfly Conservation Europe (BCE) consortium, a partnership organisation focused on the conservation of butterflies, moths and their habitats throughout Europe (http://www.bc-europe.eu/). The species list of the Macaronesian islands (Tennent 2005) was updated using Vieira and Karsholt (2010) and Vieira (2017) for the

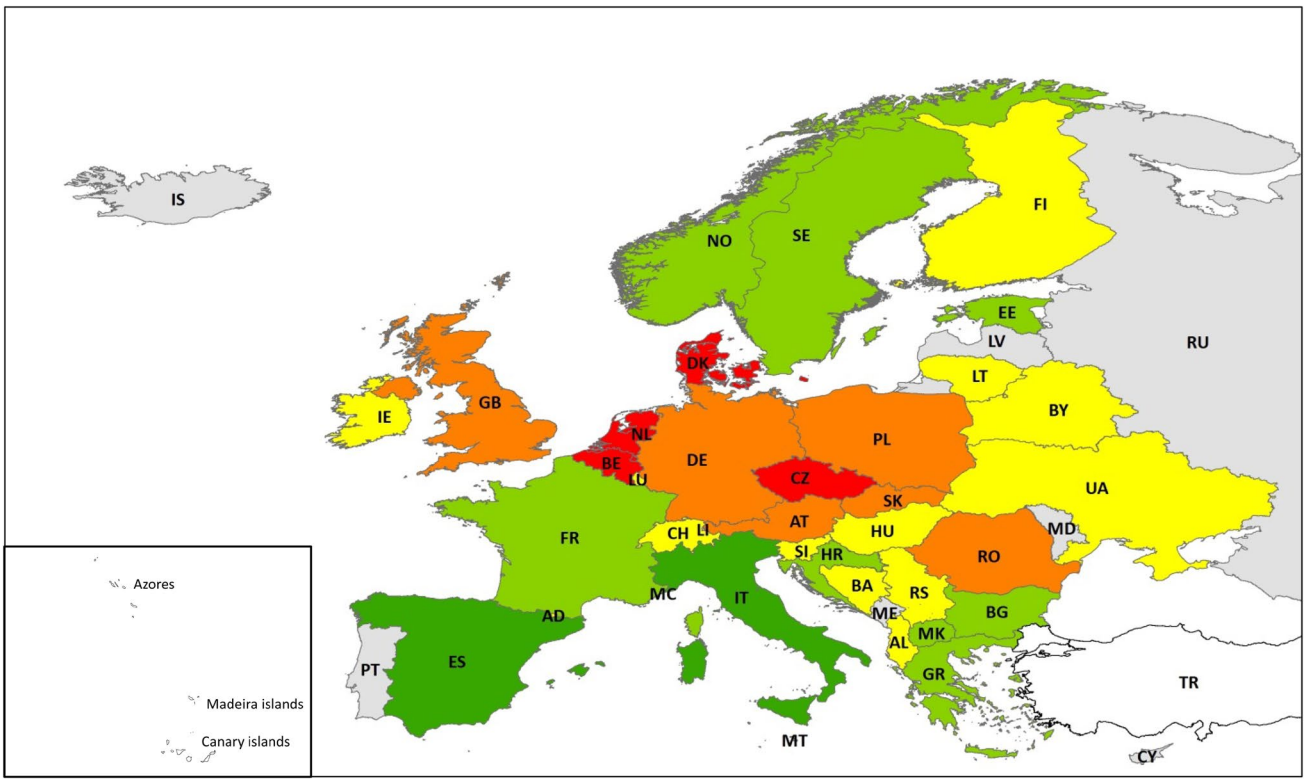

Fig. 1 Mean Red List value (cRLV) per European country (country abbreviations are the same as in Table 1). Red = cRLV ≥ 30, Orange = cRLV 20–30, Yellow = cRLV 10–20, Light green = cRLV 5–10, Dark green = cRLV ≤ 5, Grey = no Red List available. Inset: Macaronesian archipelagos. (Color figure online)

Azores, and Báez and Oromí (2010) and Monasterio León et al. (2017) for the Canary Islands. We used locally published species lists and matched them with the most recent taxonomical knowledge and species distribution information as used in the newly updated list of European butterflies. In total, 496 species were considered as being part of the European butterfly fauna, including the Macaronesian archipelagos (Wiemers et al. 2018). 148 (30%) of these species are endemic to the European continent. *Cacyreus marshalli* Butler, 1897 was accidentally introduced from South Africa into southern Europe in 1988 and is now well established in many Mediterranean countries (Paradiso et al. 2019). We considered it as being part of the national fauna in those countries where it is able to overwinter naturally, but excluded it from countries where it can only survive in greenhouses or where it is occasionally introduced with *Pelargonium* plants. Species for which the presence in a country needs confirmation were excluded from the analysis. For 54 species (11%), Europe lies at the (northern or western) edge of their distribution range. A species was considered as edge species when its population has less than 5% of its total range in Europe.

Apart from national species lists, we also compiled all available information regarding national Red Lists. Such lists were available for 34 out of the 42 European countries (81%—Table 1). Some countries such as Germany, Russia and Spain also have Red Lists at sub-national level (i.e. Länder, provinces, counties), but when a national Red List was available, we used the latter for further analysis. Belgium has separate Red Lists for the two administrative regions that are responsible for nature conservation: Flanders (northern Belgium; Maes et al. 2012) and Wallonia (southern Belgium; Fichefet et al. 2008) and does not have a national Red List for the whole country. Therefore, we combined the regional Red Lists into a Belgian Red List by (conservatively) taking the lowest extinction risk category of the two regions as the Belgian Red List category. Russia has a relatively old national Red List (Iliashenko and Iliashenko 2000; Danilov-Danilian 2001), but only four butterfly species are assessed as declining. We only used relatively recent Red Lists (≥ 2005), which excluded Russia (2001), reducing the number of Red Lists to 33 for this analysis.

For further analyses, we first attributed numerical values to the different Red List categories in the European countries: regionally extinct = 100; critically endangered = 80; endangered = 50; vulnerable = 30; near threatened = 20; least concern = 1; data deficient = 1; unknown = 1—i.e. there is a Red List for butterflies in the country and the

Table 1 Number of species (Nspecs, with the number of endemic species (Nend) between brackets) and Red List species (NRLspec, criteria used for the Red List assessment: ^{IUCN} = IUCN criteria, ^{NC} = national criteria, ^{EJ} = expert judgement) per country together with the country code used in Fig. 1 and references for the species lists and the Red Lists. Only resident species and regular migrants are taken into account

Country	Code	Nspecs	Reference species list	NRLspec	Reference Red List
Albania	AL	201	Verovnik and Popović (2013), Micevski et al. (2015) and Šašić et al. (2015b) Cuvelier et al. (2018)	55^{IUCN}	Anonymous (2013)
Andorra	AD	151	Dantart and Jubany (2012)	31^{IUCN}	Dantart and Jubany (2012)
Austria	AT	205	Huemer (2013); Huemer and Wiesmair (2017)	63^{NC}	Zulka et al. 2003; Höttinger and Pennerstorfer (2005)
Belarus	BY	133	Korb and Bolshakov (2016)	23^{EJ}	Kulak and Yakovlev (2018)
Belgium	BE	112	Fichefet et al. (2008) and Maes et al. (2012)	55^{IUCN}	Fichefet et al. (2008) and Maes et al. (2012)
Bosnia and Herzegovina	BA	195	Koren and Kulijer (2016); Lelo (2016)	29^{IUCN}	Đug (2013)
Bulgaria	BG	217	Langourov and Simov (2014), Kolev and Shtinkov (2016), Kolev (2017) and Kolev and Tsvetanov (2018)	47^{IUCN}	Hristova and Beshkov (2017)
Croatia	HR	196	Šašić and Mihoci (2011) and Šašić et al. (2015a)	15^{IUCN}	Šašić et al. (2015a)
Cyprus	CY	48 (3)	John and Skule (2016)	–	–
Czech Republic	CZ	157	Alois Pavlíčko and Zdeněk Faltýnek Fric (pers. comm.)	75^{IUCN}	Beneš and Konvička (2017)
Denmark	DK	84	Aarvik et al. (2017)	38^{IUCN}	Wind and Pihl (2004)
Estonia	EE	104	Aarvik et al. (2017) and Õunap and Tartes (2014)	13^{IUCN}	Anu Tiitsaar (pers.comm.)
Finland	FI	110	Aarvik et al. (2017) and Saarinen and Jantunen (2013)	23^{IUCN}	Kaitila et al. (2010)
France	FR	255	Lafranchis et al. (2015)	17^{IUCN}	UICN France et al. (2012)
Germany	DE	178	Reinhardt and Bolz (2011)	71^{NC}	Reinhardt and Bolz (2011)
Greece	GR	235 (8)	Pamperis (2009) and Coutsis and Bozano (2017)	30^{EJ}	Pamperis (2009), Legakis and Maragou (2009)
Hungary	HU	156	Varga (2012), Sáfián et al. (2012) and Gergely et al. (2017)	48^{EJ}	Ádám Kőrösi & Ádám Gór (pers. comm.)
Iceland	IS	2	Erling Ólafsson (pers. comm.), Ole Karsholt (pers. comm.)	–	–
Ireland	IE	35	Tomás Murray (pers. comm.)	6^{IUCN}	Regan et al. (2010)
Italy	IT	272 (9)	Balletto et al. (2014)	15^{IUCN}	Bonelli et al. (2018)
Latvia	LV	118	Aarvik et al. (2017)	–	–
Liechtenstein	LI	122	Aistleitner and Aistleitner (1996), Hiermann (pers. comm.)	–	–
Lithuania	LT	120	Aarvik et al. (2017)	21^{IUCN}	Rašomavičius (2007)
Luxembourg	LU	88	Mestdagh et al. (in press)	24^{IUCN}	Mestdagh et al. (in press)
FYR of Macedonia	MK	203 (1)	Micevski and Micevski (2017)	12^{IUCN}	Krpač and Darcemont (2011)
Malta	MT	23	Valletta (1972), Schembri (1968), Sammut (2000) and Cassar (2018)	–	–
Moldova	MD	124	Korb and Bolshakov (2016) and Mølgaard (2017)	–	–
Montenegro	ME	183	Švara et al. (2015) and Franeta (2018)	–	–
Netherlands	NL	77	Kuchlein and de Vos (1999) and van Swaay (2018)	42^{NC}	Bos et al. (2006)
Norway	NO	96	Aarvik et al. (2017)	11^{IUCN}	Henriksen and Hilmo (2015)
Poland	PL	154	Buszko and Masłowski (2015)	63^{EJ}	Buszko and Nowacki (2002) and Buszko and Sielezniew (pers. comm.)

Table 1 (continued)

Country	Code	Nspecs	Reference species list	NRLspec	Reference Red List
Portugal	PT	133	Garcia-Pereira et al. (2003) and Marabuto and Maravalhas (2008)	–	–
Romania	RO	193	Székely (2008), Korb and Bolshakov (2016), Wiemers et al. (2018)	65^{EJ}	Rákosy (2013) and Vlad Dincă (pers. comm.)
Russia	RU	258	Tshikolovets (2011), Tuzov (1997), Tuzov (2000); Verovnik (pers. comm.) Tatarinov and Gorbunov (2014)	–	Iliashenko and Iliashenko (2000) and Danilov-Danilian (2001)
Serbia	RS	198	Popović and Verovnik (2018)	24^{IUCN}	Jakšić (2003) and Popović et al. (2017)
Slovakia	SK	172	Pastorális et al. (2013)	85^{IUCN}	Hernik Kalivoda (pers. comm.)
Slovenia	SI	179	Verovnik et al. (2012)	49^{EJ}	Anonymous (2002); Verovnik et al. (2012)
Spain	ES	233 (13)	García-Barros et al. (2013) and Monasterio León et al. (2017)	6^{IUCN}	Verdú and Galante (2009) and Verdú et al. (2011)
Sweden	SE	111	Ahrné et al. (2015)	15^{IUCN}	Ahrné et al. (2015)
Switzerland	CH	202	Sonderegger (2005), SwissLepTeam (2010) and Wermeille et al. (2014)	63^{IUCN}	Wermeille et al. (2014)
Ukraine	UA	200 (1)	Nekrutenko and Tshikolovets (2005) and Korb and Bolshakov (2016)	65^{EJ}	Popov and Geryak (pers. comm.)
United Kingdom	GB	63	Newland et al. (2015)	23^{IUCN}	Fox et al. (2011)
Macaronesion archipelagos					
Azores (PT)	MA_AZ	8 (2)	Tennent (2005), Vieira and Karsholt (2010), Wiemers (pers. comm.)	–	–
Madeira Islands (PT)	MA_MA	15 (4)	Tennent (2005), Wiemers (pers. comm.)	–	–
Canary Islands (ES)	MA_CA	33 (13)	Tennent (2005), Báez and Oromí (2010), Wiemers (pers. comm.)	–	–

Only actually breeding, extinct and regular migrants are taken into account

species is present in the country, but it is not mentioned on the Red List (cf. Maes et al. 2012). These values are based upon the thresholds of decline for classifying species in the respective Red List categories (> 80% decline = critically endangered, > 50% decline = endangered, > 30% decline = vulnerable, etc.). Next, we calculated a mean Red List value per country (cRLV) and a weighted Red List value per species (wsRLV) using the square root of the area (instead of the area as such) of the countries in which each species was assessed as a weighting factor (i.e. the Red List value divided by the square root of the countries' area). The square root of the area of the country was used to reduce the impact of very large countries on the wsRLV. Some of the countries did not use IUCN criteria, but had a similar classification as the one used by the IUCN. For these countries, the numerical values were attributed in the same way as for the countries that used IUCN criteria. Some countries (Bulgaria, Greece and the Former Yugoslav Republic of Macedonia and Slovakia), however, used a lower number of categories (usually lumping the "Critically Endangered" category and the "Endangered" category). In those cases, an intermediate value of 65 (the mean of 80 and 50) was given as a numerical Red List Value to the nationally used category "Endangered".

Results

Twenty-three out of 33 European countries (70%) used IUCN criteria to assess the Red List status of butterflies, seven (21%) used expert judgement (Belarus, Greece, Hungary, Poland, Romania, Slovenia and Ukraine) and three (9%) used national criteria (Austria—Zulka et al. 2003; Germany—Ludwig et al. 2006, 2009; the Netherlands—de Iongh and Bal 2007; Table 1).

The most species-rich countries in Europe are Italy (272 species), Russia (258) and France (255—Table 1) followed by some of the Mediterranean (Greece and Spain), Balkan Peninsula (Bulgaria, the Former Yugoslav Republic of Macedonia and Albania), Alpine countries (Austria and Switzerland) and the Ukraine with more than 200 butterfly species. Countries with relatively low species-richness are island states such as Iceland (only the two migrant species *Vanessa atalanta* and *V. cardui*), Malta (23 species), Ireland

(35 species) and Cyprus (48 species). In Europe (excluding the Macaronesian archipelagos), 35 species are considered as endemic on a national scale, with the highest endemism situated in the Mediterranean (Table 1): Spain (13 endemics), Italy (9, of which 4 on the mainland, 2 on Sardinia and 1 each on Sicily, the Aeolian Islands and the Pontine Islands) and Greece (8, of which 2 on the mainland, 4 on Crete and 1 each on the islands of Chios and Karpathos) and Cyprus (3). Two other European countries each have 1 endemic butterfly species: the Former Yugoslav Republic of Macedonia (*Pseudochazara cingovskii*) and Ukraine (*Pseudochazara euxina*).

A total of 44 species are present (including the irregular vagrant *Hypolimnas misippus*) on the Macaronesian archipelagos (including 20 endemics) of which 33 are resident on the Canary Islands (13 endemics), 15 on the Madeira Islands (4 endemics, including the globally extinct *Pieris wollastoni*) and 8 on the Azores (2 endemics—Table 2). *Vanessa vulcania* is present in both Madeira and the Canary Islands. There are no Red Lists available for the Macaronesian archipelagos, but seven of the endemic species on the Macaronesian archipelagos were assessed as being threatened in Europe: *Pieris wollastoni, Pararge xiphia* and *Gonepteryx maderensis* on the Madeira islands and *Gonepteryx cleobule, Hipparchia bacchus, Hipparchia tilosi* and *Pieris cheiranthi* on the Canary islands (van Swaay et al. 2010; Table 2).

The countries with a mean Red List Value (cRLV) ≥ 30 are the Netherlands, Belgium, the Czech Republic and Denmark (Table 1). The spatial distribution of the mean Red List Value is highest in NW Europe and more or less decreases concentrically towards the edges of Europe with the lowest mean Red List Values in the Mediterranean region, e.g. Spain, France and Italy (Figs. 1, 2).

Regarding the weighted Red List Value (wsRLV) per species, five species that were assessed in more than one country had a weighted Red List value ≥ 50 (i.e. would qualify for the Red List category Endangered; Table 3): *Colias myrmidone, Pseudochazara orestes, Tomares nogelii, Colias chrysotheme* and *Coenonympha oedippus* (in decreasing order of wsRLV). Apart from these five species, 13 species also had a wsRLV ≥ 50, but were only assessed in a single country (Table 3). Two of these species were classified as being of Least Concern on the European Red List of butterflies (*Oeneis tarpeia*—Regionally Extinct in the Ukraine and *Tomares callimachus*—Endangered in the Ukraine; van Swaay et al. 2010). These two species are also present in Russia, where no recent Red List status is available. Three of the species that were only assessed in a single country were classified as Endangered (*Turanana taygetica, Agriades zullichi* and *Polyommatus humedasae*) and one as Vulnerable (*Polyommatus golgus*) on the European Red List of butterflies (van Swaay et al. 2010). Of the species that are considered as Least Concern on the European Red List of butterflies (van Swaay et al. 2010) and that were assessed in more than one country, 17 species had a weighted Red List Value between 30 and 50 (i.e. would qualify as Vulnerable): *Nymphalis vaualbum, Neolysandra coelestina, Muschampia tessellum, Freyeria trochylus, Pseudophilotes baton, Pseudochazara geyeri, Phengaris alcon, Pseudophilotes bavius, Kirinia climene, Pontia chloridice, Erebia rhodopensis, Polyommatus admetus, Boloria aquilonaris, Pyrgus onopordi, Polygonia egea, Euphydryas aurinia* and *Euchloe penia* (Tables 2, 3). Four more Least Concern species on the European Red List had a wsRLV between 30 and 50, but were only assessed in one country: *Chazara persephone, Neolycaena rhymnus* and *Satyrus virbius* (Vulnerable) in the Ukraine but they also occur in Russia where no Red List status is available and *Hipparchia christenseni* which is a Vulnerable endemic in Greece (Table 3).

When looking at the species in the European Union, 24 species had a weighted Red List value ≥ 50 (Table 3), of which ten were assessed in more than one country: *Colias myrmidone, Nymphalis vaualbum, Pseudochazara orestes, Colias chrysotheme, Lycaena helle, Coenonympha hero, Coenonympha oedippus, Muschampia tessellum, Agriades dardanus* and *Polyommatus orphicus*. Thirteen more species had a weighted Red List value ≥ 50, but were only assessed in a single country (Tables 2, 3).

Four species with a wsRLV ≥ 50 were assessed as being of Least Concern in the European Union: *Lycaena helle, Coenonympha oedippus, Muschampia tessellum*, and *Pseudochazara geyeri*. Among the species of the Habitats Directive, six had a weighted Red List value ≥ 30 (i.e. the threshold for being classified as Vulnerable) but were classified as being of Least Concern in the European Union (van Swaay et al. 2010): *Lycaena helle, Coenonympha oedippus, Pseudophilotes bavius, Euphydryas maturna, Agriades aquilo* and *Euphydryas aurinia* (Tables 2, 3).

Discussion

By compiling 42 national butterfly species lists and 33 recent Red Lists of European countries, we were able to apply an alternative way of ranking both the countries (using the mean Red List value) and the species of European conservation concern (using a weighted Red List value). Countries with the highest mean Red List value are mainly situated in NW and Central Europe. Of the species that were assessed in more than one country, 14 species have relatively high weighted Red List values (≥ 30, i.e. the threshold value to qualify for Vulnerable) but are not classified as threatened on the European Red List (van Swaay et al. 2010) and are not listed in the annexes of the European Habitats Directive.

Thirty-three out of 42 European countries (79%) have a recent (i.e. ≥ 2005) national Red List of butterflies. The majority of them (28 out of 33, i.e. 85%) date from after

Table 2 Species lists for the Macaronesian archipelagos together with their Red List category (RLCEur) on the European Red List of butterflies (van Swaay et al. 2010)

Species name		Canary Islands							Madeira Islands		Azores								
	RLCEur	EH	Fu	GC	LG	LP	La	Tn	Ma	PS	Co	Fa	Fl	Gr	Pi	SMa	SJ	SMi	Tr
Argynnis pandora	LC	+	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Aricia cramera	LC	+	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Azanus ubaldus	NA	.	+	+	.	(+)	.	(+)	.	.	.	.	.	.	.	.	.	.	.
Cacyreus marshalli	NA	.	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.
Catopsilia florella	NA	+	+	+	+	+	+	+	(+)	.	.	.	.	.	.	.	.	.	.
Colias crocea	LC	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cyclyrius webbianus	LC	(+^{E})	.	+^{E}	+^{E}	+^{E}	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.
Danaus chrysippus	NA	.	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Danaus plexippus	NA	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Euchloe charlonia	LC	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Euchloe eversi	LC	.	.	.	.	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.
Euchloe grancanariensis	LC	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euchloe hesperidum	LC	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gonepteryx cleobule	VU	.	.	.	+^{E}	+^{E}	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.
Gonepteryx maderensis	EN	.	.	.	.	.	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.
Hipparchia azorina	LC	.	.	.	.	.	.	.	.	.	+^{E}	+^{E}	+^{E}	.	+^{E}	.	+^{E}	+^{E}	+^{E}
Hipparchia bacchus	VU	+^{E}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hipparchia gomera	LC	.	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hipparchia maderensis	LC	.	.	.	.	.	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.
Hipparchia miguelensis	LC	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+^{E}	.
Hipparchia tamadabae	LC	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hipparchia tilosi	VU	.	.	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.	.	.
Hipparchia wyssii	LC	.	.	.	.	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.
Hypolimnas misippus	–	.	.	.	(+)	.	.	(+)	(+)	(+)	.	.	.	.	.	.	.	(+)	.
Issoria lathonia	LC	.	.	(+)	(+)	(+)	.	(+)	+	.	.	.	.	.	.	.	.	.	.
Lampides boeticus	LC	+	+	+	+	+	+	+	+	+	.	+	+	+	+	+	+	+	+
Leptotes pirithous	LC	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.
Lycaena phlaeas	LC	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.
Maniola jurtina	LC	+	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.
Pararge aegeria	LC	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
Pararge xiphia	EN	.	.	.	.	.	.	.	+^{E}	.	.	.	.	.	.	.	.	.	.
Pararge xiphioides	LC	+^{E}	.	+^{E}	+^{E}	+^{E}	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.
Pieris brassicae	LC	.	(+)	.	.	.	(+)	.	.	.	+	+	+	+	+	+	+	+	+
Pieris cheiranthi	EN	.	.	.	+†	+^{E}	.	+$^{E+}$	.	.	.	.	.	.	.	.	.	.	.
Pieris rapae	LC	+	+	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.
Pieris wollastoni	CR	.	.	.	.	.	.	.	+^{E†}	.	.	.	.	.	.	.	.	.	.
Polyommatus celina	–	.	+	.	.	.	+	(+)	.	.	.	.	.	.	.	.	.	.	.
Pontia daplidice	LC	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.
Thymelicus christi	LC	+^{E}	.	+^{E}	+^{E}	+^{E}	.	+^{E}	.	.	.	.	.	.	.	.	.	.	.
Vanessa atalanta	LC	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vanessa cardui	LC	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Vanessa virginiensis	NA	(+)	.	(+)	(+)	(+)	.	(+)	.	.	(+)	(+)	.	.	(+)	.	(+)	(+)	.
Vanessa vulcania	LC	+	(+)	+	+	+	.	+	+	+	.	.	.	.	.	.	.	.	.
Zizeeria knysna	NA	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.
Total		18^{1}	17^{1}	22^{2}	23^{1}	23^{1}	14	24^{2}	15^{4}	10	6	7	7	6	7	6	7	8^{1}	7

Azores: *Co* Corvo, *Fa* Faial, *Fl* Flores, *Gr* Graciosa, *Pi* Pico, *SMa* Santa Maria, *SJ* Sao Jorge, *SMi* Sao Miguel, *Tr* Terceira. + resident populations, (+) only as a migrant; ^{E} = endemic to the island or archipelago. "." = absent. The number of breeding endemics per island is given in superscript

Canary Islands: *EH* El Hierro, *Fu* Fuerteventura, *GC* Gran Canaria, *LG* La Gomera, *LP* La Palma, *La* Lanzarote, *Tn* Tenerife

Madeira Islands: *Ma* Madeira, *PS* Porto Santo

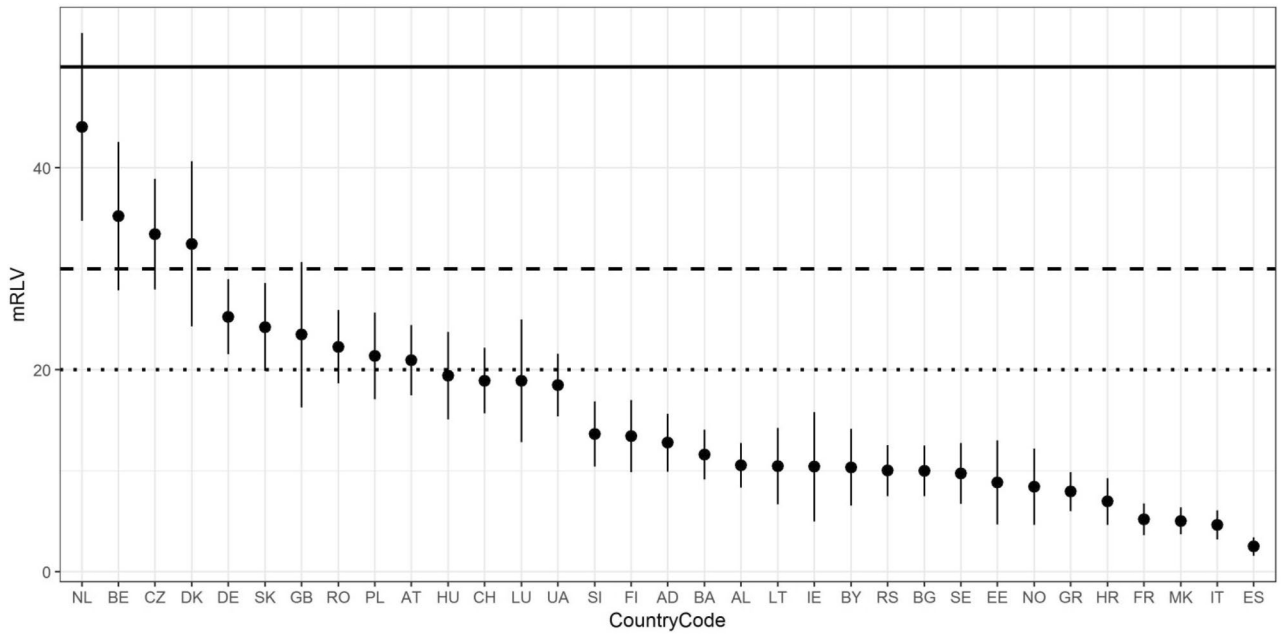

Fig. 2 Mean Red List value per country (cRLV) with 95% confidence intervals. Country codes are the same as in Table 1. Horizontal lines indicate the values 50 (solid line), 30 (dashed line) and 20 (dotted line)

the compilation of the most recent European Red List of butterflies (van Swaay et al. 2010). This updated knowledge on national butterfly status will be very useful for the next European Red List assessment, especially because most of the European countries used regional IUCN criteria and/or categories for the national Red Lists assessments (Table 1). Three countries used their own national criteria and seven countries used expert judgement to classify species in Red List categories (Table 1). In the Netherlands, for example, the legally binding Red List (van Swaay 2006) was compiled using national criteria (de Iongh and Bal 2007). To compare the outcome with the use of IUCN criteria, however, a second Red List was made using the IUCN criteria for regional use resulting sometimes in different classifications for a number of species (van Swaay 2006). In other countries and for other species, however, such comparisons between national and IUCN criteria resulted in similar Red List classifications (e.g. Eaton et al. 2005 for birds in the UK). The suitability of IUCN criteria for Red List assessments of invertebrates has been criticised because of a supposed lack of data to apply the IUCN criteria correctly (Cardoso et al. 2011, 2012). For butterflies, however, both trend and distribution data are becoming increasingly available in many European countries. Depending on the availability, however, countries use either abundance data (monitoring data—van Swaay et al. 2016) or distribution data (often opportunistic data—Maes et al. 2015) to calculate "population" trends (i.e. criterion A for the IUCN Red List assessments). For comparisons among countries, it is recommended that similar methods are used for the trend calculations in Red List assessments.

Although IUCN Red List criteria are largely quantitative, the interpretation of the criteria and the data availability still differs strongly among European countries. The previous European Red List of butterflies, for example, was mainly based on expert judgement in the respective countries (van Swaay et al. 2010). Compared with other taxonomic groups for which European Red Lists have been compiled, a relatively low number of butterflies (38 out of 435 assessed species or 9%) were classified as threatened (Regionally extinct, Critically Endangered, Endangered or Vulnerable—van Swaay et al. 2011). Only bees have a lower proportion of threatened species on the European Red List, but that is mainly due to the large number of Data Deficient species (Nieto et al. 2014).

The open access availability of the national Red List statuses of butterflies throughout Europe would be very helpful when applying the rescue criterion used in regional Red Lists (IUCN 2012), where a Red List category could be lowered (depending on the species' mobility) when a species is not threatened in the neighbouring countries or regions or upgraded when the neighbouring populations are considered as sinks. In countries where nature conservation legislation is regionalised (e.g. Belgium, Germany, Spain), it remains more appropriate to compile Red Lists on a sub-national level (cf. Maes et al. 2012). We also encourage local authorities or authors to make national or regional Red Lists available via open access platforms such as GBIF and, if possible,

Table 3 Species list of Europe indicating whether the species is a European endemic (EE, i.e. species that only occurs in Europe) and if the species has a larger distribution range outside Europe and reach the edge of their distribution range in Europe (EoR), the weighted Red List value per species in Europe (wsRLVEur) and in the European Union (wsRLVEU), the number of countries in which the species occurs in Europe (#CoEur) and in the European Union (#CoEU), the number of countries in which the species has a Red List status in Europe (#CoRLEur) and in the European Union (#CoRLEU), the Red List category in Europe (RLCEur) and in the European Union (*RLCEU-RE* regionally extinct, *CR* critically endangered, *EN* endangered, *VU* vulnerable, *NT* near threatened, *LC* least concern, *DD* data deficient, *NA* not assessed, *NE* not evaluated—van Swaay et al. 2010), the Annexes of the Habitats Directive in which the species is listed (HD) and the country (region) for which the species is endemic. Taxonomy is according to Wiemers et al. (2018)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Oeneis tarpeia	–	–	100	2	1	LC	–	–	–	NE	–	–
Turanana taygetica	–	EoR	80	1	1	EN	80	1	1	EN	–	–
Coenonympha phryne	–	–	80	2	1	CR	–	–	–	NE	–	–
Colias myrmidone	–	–	74.05	14	12	EN	78.43	10	9	CR	II+IV	–
Pseudochazara orestes	EE	–	64.35	2	2	VU	64.35	2	2	VU	–	–
Tomares nogelii	–	EoR	61.58	3	2	VU	80	1	1	RE	–	–
Colias chrysotheme	–	–	55.72	8	6	VU	58.52	5	5	VU	–	–
Coenonympha oedippus	–	–	52.11	15	13	EN	53.63	10	10	LC	II+IV	–
Kretania eurypilus	–	EoR	50	2	1	NA	50	1	1	NA	–	–
Pelopidas thrax	–	EoR	50	2	1	NA	50	2	1	NA	–	–
Tomares callimachus	–	EoR	50	2	1	LC	–	–	–	NE	–	–
Agriades zullichi	EE	–	50	1	1	EN	50	1	1	EN	–	Spain
Hipparchia sbordonii	EE	–	50	1	1	NT	50	1	1	NT	–	Italy—Pontine Islands
Maniola megala	–	EoR	50	1	1	NA	50	1	1	NA	–	–
Polyommatus golgus	EE	–	50	1	1	VU	50	1	1	VU	II+IV	Spain
Polyommatus humedasae	EE	–	50	1	1	EN	50	1	1	EN	–	Italy
Polyommatus iphigenia	–	EoR	50	1	1	NA	50	1	1	NA	–	–
Satyrium ledereri	–	EoR	50	1	1	NA	50	1	1	NA	–	–
Lycaena helle	–	–	49.96	22	20	EN	54.9	15	15	LC	II+IV	–
Coenonympha hero	–	–	48.34	18	16	VU	54.75	13	12	VU	IV	–
Nymphalis vaualbum	–	–	46.42	13	11	LC	70.22	9	8	VU	II+IV	–
Polyommatus damon	–	–	45.95	24	20	NT	44.41	14	13	NT	–	–
Erebia christi	EE	–	44.6	2	2	VU	50	1	1	VU	II+IV	–
Muschampia cribrellum	–	–	44.48	7	6	NT	41.72	3	3	NT	–	–
Leptidea morsei	–	–	42.62	13	11	NT	45.32	8	8	EN	II+IV	–
Pyrgus cirsii	EE	–	42.41	6	6	VU	39.53	4	4	VU	–	–
Erebia sudetica	EE	–	42.04	5	5	VU	43.22	4	4	VU	IV	–
Chazara briseis	–	–	41.62	25	21	NT	46.42	15	14	NT	–	–
Euphydryas maturna	–	–	40.93	28	24	VU	46.24	19	18	LC	II+IV	–
Polyommatus orphicus	EE	–	40.83	3	3	VU	50	2	2	VU	–	–
Aricia anteros	–	–	40.57	10	9	NT	34.98	4	4	LC	–	–
Neolysandra coelestina	–	EoR	40.44	3	2	LC	20	1	1	LC	–	–
Phengaris teleius	–	–	40.39	21	18	VU	41.97	15	14	VU	II+IV	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Muschampia tessellum	–	–	39.83	7	6	LC	53.17	3	3	LC	–	–
Polyommatus nephohiptamenos	EE	–	39.57	2	2	NT	39.57	2	2	NT	–	–
Parnassius apollo	–	–	38.88	26	23	NT	34.39	15	15	NT	IV	–
Freyeria trochylus	–	–	38.79	3	2	LC	38.79	3	2	LC	–	–
Boloria titania	–	–	38.23	19	15	NT	32.65	11	10	LC	–	–
Pseudophilotes baton	EE	–	38.22	11	10	LC	38.7	9	8	LC	–	–
Agriades dardanus	–	–	38.2	5	4	NT	50	2	2	NT	–	–
Pseudochazara geyeri	–	–	38.17	3	3	LC	50	1	1	LC	–	–
Phengaris alcon	–	–	37.55	33	28	LC	39.63	22	20	NT	–	–
Phengaris nausithous	–	–	37	18	16	NT	38.17	13	13	NT	II + IV	–
Pseudophilotes bavius	–	–	35.86	7	6	LC	49.24	3	3	LC	II + IV	–
Kirinia climene	–	–	35.44	9	7	LC	49.96	3	3	LC	–	–
Pontia chloridice	–	–	35.43	6	4	LC	40.43	3	2	LC	–	–
Coenonympha tullia	–	–	35.32	25	23	VU	38.6	19	18	NT	–	–
Erebia rhodopensis	EE	–	35.05	6	5	LC	40.43	2	2	LC	–	–
Iolana iolas	–	–	34.7	15	14	NT	33.25	9	9	NT	–	–
Pseudochazara amymone	EE	–	34.41	2	2	VU	50	1	1	VU	–	–
Lopinga achine	–	–	34.29	26	23	VU	30.7	19	18	VU	IV	–
Carcharodus lavatherae	–	–	33.53	22	19	NT	33.07	12	12	NT	–	–
Polyommatus admetus	–	–	33.07	12	11	LC	39.84	7	7	LC	–	–
Boloria improba	–	–	32.9	4	3	EN	39.29	2	2	EN	II	–
Phengaris arion	–	–	32.59	36	31	EN	36.07	24	23	EN	IV	–
Boloria aquilonaris	–	–	32.18	20	18	LC	32.7	15	14	LC	–	–
Melitaea britomartis	–	–	31.44	18	17	NT	35.45	13	13	NT	–	–
Pyrgus onopordi	–	–	31.37	7	6	LC	27.76	6	5	LC	–	–
Polygonia egea	–	–	31.33	12	10	LC	37.23	7	7	LC	–	–
Euphydryas aurinia	–	–	31.24	37	32	LC	32.53	26	24	LC	II	–
Euchloe penia	–	–	31.18	4	4	LC	38.79	2	2	LC	–	–
Pseudophilotes vicrama	–	–	30.54	26	21	NT	37.49	17	15	NT	–	–
Zizeeria karsandra	–	EoR	30	4	2	NA	30	4	2	NA	–	–
Kretania trappi	EE	–	30	2	2	NT	30	1	1	LC	–	–
Chazara persephone	–	–	30	2	1	LC	–	–	–	NE	–	–
Kretania pylaon	–	–	30	2	1	NT	–	–	–	NE	–	–
Neolycaena rhymnus	–	–	30	2	1	LC	–	–	–	NE	–	–
Polyommatus damocles	–	–	30	2	1	DD	–	–	–	NE	–	–
Satyrus virbius	EE	–	30	2	1	LC	–	–	–	NE	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Polyommatus damone	–	EoR	30	2	1	NA	–	–	–	NA	–	–
Hipparchia christenseni	EE	–	30	1	1	LC	30	1	1	LC	–	Greece—Karpathos
Pseudochazara cingovskii	EE	–	30	1	1	CR	–	–	–	NE	–	FYR of Macedonia
Pseudochazara euxina	EE	–	30	1	1	EN	–	–	–	NE	–	Ukraine
Gonepteryx farinosa	–	–	29.78	5	4	LC	38.79	2	2	LC	–	–
Gegenes pumilio	–	–	29.48	11	8	LC	29.99	8	6	LC	–	–
Hipparchia statilinus	–	–	29.45	29	25	NT	31.67	18	17	NT	–	–
Polyommatus eros	–	–	29.44	22	19	NT	19.2	11	11	NT	–	–
Colias palaeno	–	–	27.94	20	17	LC	28.8	14	13	LC	–	–
Boloria freija	–	–	27.8	7	5	LC	22.93	4	3	LC	–	–
Boloria polaris	–	–	27.55	4	3	VU	40.71	2	2	VU	–	–
Erebia neleus	EE	–	27.15	8	7	–	41.21	3	3	–	–	–
Zegris eupheme	–	–	26.67	3	2	NT	1	1	1	NT	–	–
Scolitantides orion	–	–	26.39	27	24	LC	25.86	16	16	NT	–	–
Cupido osiris	–	–	25.73	21	18	LC	26.46	12	12	LC	–	–
Melitaea aurelia	–	–	25.59	29	24	NT	30.29	18	17	LC	–	–
Hyponephele lupina	–	–	25.32	19	15	LC	29.88	12	10	LC	–	–
Polyommatus dorylas	–	–	24.91	27	25	NT	20.96	17	17	NT	–	–
Hipparchia hermione	–	–	24.76	17	14	NT	26.05	11	9	NT	–	–
Carcharodus baeticus	EE	–	24.67	5	4	LC	17	4	3	LC	–	–
Oeneis jutta	–	–	24.64	10	8	LC	23.36	6	5	LC	–	–
Neptis rivularis	–	–	24.63	22	19	LC	30.81	12	12	LC	–	–
Agriades optilete	–	–	24.11	23	21	LC	26.84	16	15	LC	–	–
Erebia orientalis	EE	–	24.1	2	2	LC	1	1	1	LC	–	–
Zerynthia cerisy	–	–	23.99	9	8	NT	31.03	5	4	NT	–	–
Limenitis populi	–	–	23.97	31	28	LC	26.85	22	21	NT	–	–
Carterocephalus silvicola	–	–	23.72	14	12	LC	25.88	10	9	LC	–	–
Pyronia tithonus	–	–	23.64	28	26	LC	18.44	20	19	LC	–	–
Melanargia russiae	–	–	23.49	12	9	LC	12.33	6	5	LC	–	–
Argynnis laodice	–	–	23.33	12	10	LC	24.88	9	8	NT	–	–
Agriades aquilo	–	–	23.02	4	3	LC	33.93	2	2	LC	II	–
Carcharodus floccifera	–	–	23.02	28	24	NT	21.35	17	16	LC	–	–
Anthocharis gruneri	–	–	23.02	5	5	LC	14.87	2	2	LC	–	–
Hamearis lucina	–	–	22.99	35	29	LC	19.66	23	21	LC	–	–
Parnassius mnemosyne	–	–	22.92	32	28	NT	24.18	20	19	LC	IV	–
Hyponephele lycaon	–	–	22.41	30	25	LC	27.94	19	17	LC	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Neptis sappho	–	–	22.25	19	16	LC	32.25	11	11	LC	–	–
Proterebia phegea	–	–	22.17	5	4	LC	20	2	2	LC	–	–
Boloria eunomia	–	–	22.12	22	20	LC	19.5	16	15	LC	–	–
Kretania sephirus	–	–	22.06	11	8	LC	23	4	4	LC	–	–
Melitaea arduinna	–	–	21.99	7	6	LC	9.16	3	3	LC	–	–
Fabriciana niobe	–	–	21.79	36	30	LC	23.25	23	21	NT	–	–
Pyrgus armoricanus	–	–	21.22	28	24	LC	22.68	19	18	LC	–	–
Melitaea diamina	–	–	20.85	35	30	LC	23	22	21	NT	–	–
Pseudochazara tisiphone	–	–	20.77	2	2	–	30	1	1	–	–	–
Arethusana arethusa	–	–	20.35	24	20	LC	19.49	14	13	LC	–	–
Boloria frigga	–	–	20.25	8	6	LC	11.37	5	4	LC	–	–
Archon apollinus	–	–	20	1	1	NT	20	1	1	LC	–	–
Chazara prieuri	–	–	20	1	1	LC	20	1	1	LC	–	–
Erebia polaris	–	–	20	3	2	LC	20	1	1	LC	II	–
Euchloe bazae[a]	EE	–	20	1	1	VU	20	1	1	VU	–	Spain
Hipparchia pellucida	–	EoR	20	2	1	LC	–	–	–	LC	–	–
Kretania hesperica	EE	–	20	1	1	LC	20	1	1	LC	–	Spain
Kretania psylorita	EE	–	20	1	1	LC	20	1	1	LC	–	Greece—Crete
Lycaena thetis	–	EoR	20	1	1	NA	20	1	1	NA	–	–
Maniola halicarnassus	–	–	20	1	1	NT	20	1	1	NT	–	–
Pseudochazara williamsi	EE	–	20	1	1	–	20	1	1	–	–	Spain
Ypthima asterope	–	EoR	20	2	1	NA	20	2	1	NA	–	–
Zerynthia cretica	EE	–	20	1	1	LC	20	1	1	LC	–	Greece—Crete
Erebia flavofasciata	EE	–	19.99	3	3	NT	19.98	2	2	NT	–	–
Spialia sertorius	–	–	19.95	19	17	LC	20.79	15	14	LC	–	–
Limenitis reducta	–	–	19.78	25	20	LC	23.51	15	13	LC	–	–
Pyrgus cinarae	–	–	19.01	8	7	LC	22.49	3	3	LC	–	–
Lycaena dispar	–	–	18.98	32	28	LC	21.91	22	21	LC	II + IV	–
Colias caucasica	–	–	18.76	8	7	LC	18.73	3	3	LC	–	–
Polyommatus thersites	–	–	18.72	27	22	LC	19.98	17	15	LC	–	–
Lycaena thersamon	–	–	18.34	18	14	LC	27.56	10	9	LC	–	–
Lycaena ottomana	–	–	18.3	6	5	LC	15.77	3	3	LC	–	–
Erynnis marloyi	–	–	18.17	4	4	LC	14.87	2	2	LC	–	–
Melitaea cinxia	–	–	18.09	37	32	LC	16.96	25	23	LC	–	–
Papilio alexanor	–	–	18.06	8	7	LC	18.86	4	4	LC	IV	–
Pyrgus carthami	–	–	18.03	26	23	LC	19.78	16	16	LC	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Zerynthia polyxena	–	–	18.02	21	18	LC	12.6	11	11	LC	IV	–
Anthocharis damone	–	–	17.97	5	5	LC	8.57	2	2	LC	–	–
Erebia manto	EE	–	17.86	14	12	LC	12.21	9	9	LC	–	–
Pyrgus warrenensis	EE	–	17.74	6	6	LC	17.54	5	5	LC	–	–
Thymelicus acteon	–	–	17.63	30	26	NT	20.39	20	18	NT	–	–
Apatura metis	–	–	17.31	14	11	LC	12.18	7	7	LC	IV	–
Spialia phlomidis	–	–	17.11	5	5	LC	14.87	2	2	LC	–	–
Satyrium ilicis	–	–	16.87	34	29	LC	18.36	23	21	LC	–	–
Coenonympha orientalis	EE	–	16.84	5	4	VU	1	1	1	DD	–	–
Colias hecla	–	–	16.81	4	3	NT	24.64	2	2	NT	–	–
Glaucopsyche alexis	–	–	16.72	35	29	LC	16.14	22	20	LC	–	–
Pyrgus alveus	–	–	16.69	33	27	LC	16.79	20	18	LC	–	–
Pyrgus serratulae	–	–	16.61	32	26	LC	18.95	20	18	NT	–	–
Aricia morronensis	EE	–	16.37	3	3	LC	15.87	2	2	LC	–	–
Erebia melas	EE	–	15.97	10	9	LC	14.83	5	5	LC	–	–
Lycaena hippothoe	–	–	15.95	30	27	LC	19.12	21	20	NT	–	–
Tomares ballus	–	–	15.87	3	2	LC	15.87	3	2	LC	–	–
Euphydryas desfontainii	–	–	15.87	3	2	NT	15.87	3	2	NT	–	–
Melitaea asteria	EE	–	15.84	3	3	LC	7.56	2	2	LC	–	–
Pyrgus sidae	–	–	15.74	15	12	LC	13.98	7	7	LC	–	–
Erebia gorge	EE	–	15.66	19	17	LC	15.64	11	11	LC	–	–
Euphydryas intermedia	–	–	15.59	6	5	LC	15.06	4	4	LC	–	–
Nymphalis xanthomelas	–	–	15.57	23	20	LC	19.25	15	14	NT	–	–
Polyommatus ripartii	–	–	15.54	14	13	LC	14.72	8	8	NT	–	–
Erebia medusa	–	–	15.33	26	22	LC	8.62	15	15	LC	–	–
Pieris mannii	–	–	15.09	22	20	LC	17.27	14	14	LC	–	–
Heteropterus morpheus	–	–	14.94	28	24	LC	14.5	19	18	LC	–	–
Erebia nivalis	EE	–	14.72	3	3	LC	13.44	2	2	LC	–	–
Pieris bryoniae	–	–	14.52	14	12	LC	14.15	10	10	LC	–	–
Plebejus argyrognomon	–	–	14.49	28	24	LC	10.63	17	16	LC	–	–
Erebia styx	EE	–	14.48	5	5	LC	9.91	4	4	LC	–	–
Spialia orbifer	–	–	14.38	16	13	LC	16.92	8	8	LC	–	–
Erebia aethiops	–	–	14.37	27	23	LC	14.42	17	16	LC	–	–
Hipparchia fagi	EE	–	14.37	22	19	NT	12.04	13	13	NT	–	–
Euchloe ausonia	–	–	14.12	14	10	LC	8.18	6	5	LC	–	–
Melitaea trivia	–	–	14.08	21	17	LC	14.41	12	11	NT	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Brenthis hecate	–	–	13.85	21	18	LC	17.12	14	13	LC	–	–
Cupido decoloratus	–	–	13.77	18	15	NT	11.52	9	9	LC	–	–
Oeneis bore	–	–	13.7	4	3	LC	20	2	2	LC	–	–
Euphydryas iduna	–	–	13.7	4	3	NT	20	2	2	NT	–	–
Boloria thore	–	–	13.7	12	10	LC	7.3	7	7	LC	–	–
Melitaea aetherie	–	–	13.68	3	2	LC	13.68	3	2	LC	–	–
Cupido alcetas	–	–	13.58	23	19	LC	11.42	13	12	LC	–	–
Erebia epiphron	EE	–	13.49	21	19	LC	14.87	13	13	LC	–	–
Pieris ergane	–	–	13.38	14	13	LC	16.11	9	9	LC	–	–
Euchloe tagis	–	–	13.28	4	3	LC	13.28	4	3	LC	–	–
Carcharodus orientalis	–	–	13.27	11	9	LC	7.52	4	4	LC	–	–
Nymphalis polychloros	–	–	13.15	37	31	LC	15.77	25	23	VU	–	–
Boloria euphrosyne	–	–	13.08	39	33	LC	17.05	26	24	LC	–	–
Boloria pales	–	–	13.08	18	16	LC	13.02	10	10	LC	–	–
Lycaena alciphron	–	–	13.01	29	24	LC	14.07	18	16	NT	–	–
Aricia nicias	–	–	13	9	8	LC	10.39	5	5	LC	–	–
Minois dryas	–	–	12.88	25	21	LC	12.98	14	14	LC	–	–
Erebia pronoe	EE	–	12.57	19	16	LC	15.08	11	11	LC	–	–
Melitaea phoebe	–	–	12.53	32	26	LC	15.27	20	18	LC	–	–
Lasiommata petropolitana	–	–	12.33	28	24	LC	11.05	17	16	LC	–	–
Melitaea parthenoides	EE	–	12.31	8	7	LC	11.15	6	5	LC	–	–
Eumedonia eumedon	–	–	12.24	33	27	LC	12.79	20	18	LC	–	–
Pyrgus cacaliae	EE	–	12.07	11	10	LC	13.13	7	7	LC	–	–
Erebia scipio	EE	–	11.92	2	2	LC	11.92	2	2	LC	–	–
Aporia crataegi	–	–	11.74	38	32	LC	11.41	26	23	LC	–	–
Erebia calcarius	EE	–	11.63	3	3	LC	11.63	3	3	LC	II + IV	–
Melitaea didyma	–	–	11.55	28	23	LC	14.59	17	15	LC	–	–
Hipparchia semele	EE	–	11.5	36	31	LC	13.57	25	23	LC	–	–
Plebejus idas	–	–	11.44	35	30	LC	14.73	22	21	LC	–	–
Satyrium w-album	–	–	11.43	37	32	LC	11.69	24	23	LC	–	–
Erebia eriphyle	EE	–	11.28	5	4	LC	12.74	3	3	LC	–	–
Aricia artaxerxes	–	–	11.27	32	28	LC	15.26	20	19	LC	–	–
Cupido minimus	–	–	11.25	39	33	LC	11.92	26	24	LC	–	–
Erebia pandrose	–	–	11.14	22	19	LC	10	12	12	LC	–	–
Erebia lefebvrei	EE	–	11.02	3	3	LC	10.74	2	2	LC	–	–
Erebia epistygne	EE	–	10.74	2	2	NT	10.74	2	2	NT	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Erebia pharte	EE	–	10.7	10	9	LC	11.25	8	8	LC	–	–
Hesperia comma	–	–	10.65	38	32	LC	12.21	25	23	LC	–	–
Polyommatus daphnis	–	–	10.59	25	22	LC	10.8	15	15	LC	–	–
Hipparchia fatua	–	–	10.41	5	4	LC	14.87	2	2	LC	–	–
Hipparchia senthes	–	–	10.41	4	4	LC	14.87	2	2	LC	–	–
Coenonympha rhodopensis	EE	–	10.27	10	9	LC	8.92	5	5	LC	–	–
Coenonympha dorus	–	–	10.24	6	5	LC	1	4	3	LC	–	–
Satyrium acaciae	–	–	10.16	25	22	LC	10.51	15	15	LC	–	–
Euphydryas cynthia	EE	–	10.16	7	6	LC	9.37	5	5	LC	–	–
Erebia disa	–	–	10	4	3	LC	14.47	2	2	LC	–	–
Polyommatus aroaniensis	EE	–	9.92	4	4	LC	14.87	2	2	LC	–	–
Leptidea duponcheli	–	–	9.91	9	7	LC	1	3	3	LC	–	–
Satyrium pruni	–	–	9.75	33	29	LC	10.75	23	22	LC	–	–
Lysandra bellargus	–	–	9.68	30	25	LC	12.76	18	17	LC	–	–
Melitaea athalia	–	–	9.44	35	30	LC	12.53	23	22	LC	–	–
Pyrgus andromedae	EE	–	9.44	21	18	LC	8.59	10	10	LC	–	–
Erebia meolans	EE	–	9.27	8	7	LC	9.92	5	5	LC	–	–
Tarucus balkanicus	–	–	9.23	8	6	LC	1	4	3	LC	–	–
Fabriciana elisa	EE	–	9.08	2	2	LC	9.08	2	2	LC	IV	–
Polyommatus dolus	EE	–	9.08	2	2	LC	9.08	2	2	LC	–	–
Spialia therapne	EE	–	9.08	2	2	LC	9.08	2	2	LC	–	–
Erebia albergana	EE	–	9.08	8	7	LC	8.92	4	4	LC	–	–
Boloria selene	–	–	9.04	34	30	LC	8.83	25	23	LC	–	–
Callophrys avis	–	–	8.97	4	3	LC	8.97	4	3	LC	–	–
Iphiclides podalirius	–	–	8.86	27	22	LC	10.61	17	16	LC	–	–
Pieris krueperi	–	–	8.76	4	4	LC	1	2	2	LC	–	–
Cyaniris semiargus	–	–	8.47	38	32	LC	11	25	23	LC	–	–
Pseudochazara amalthea	EE	–	8.43	6	6	–	1	3	3	–	–	–
Fabriciana adippe	–	–	8.35	37	31	LC	10.89	24	22	LC	–	–
Limenitis camilla	–	–	8.3	35	29	LC	10.21	24	22	LC	–	–
Erebia ligea	–	–	8.19	30	26	LC	11.18	19	18	LC	–	–
Boloria graeca	–	–	8.17	9	8	LC	6.25	4	4	LC	–	–
Brintesia circe	–	–	8.05	24	20	LC	6.06	14	13	LC	–	–
Libythea celtis	–	–	7.98	21	17	LC	4.23	13	11	LC	–	–
Apatura iris	–	–	7.85	36	31	LC	8.73	25	23	LC	–	–
Pontia callidice	–	–	7.79	9	7	LC	6.84	5	5	LC	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Polyommatus amandus	–	–	7.75	32	28	LC	6.58	20	19	LC	–	–
Erebia claudina	EE	–	7.56	2	2	NT	7.56	2	2	NT	–	–
Erynnis tages	–	–	7.47	38	32	LC	9.15	25	23	LC	–	–
Brenthis ino	–	–	7.18	36	30	LC	7.73	23	21	LC	–	–
Thecla betulae	–	–	7.15	39	33	LC	6.81	26	24	LC	–	–
Muschampia proto	–	–	7.08	11	8	LC	1	6	5	LC	–	–
Kirinia roxelana	–	–	6.96	10	8	LC	7.52	5	4	LC	–	–
Nymphalis antiopa	–	–	6.95	36	30	LC	5.39	23	21	LC	–	–
Colias tyche	–	–	6.9	4	3	LC	9.82	2	2	LC	–	–
Pyrgus centaureae	–	–	6.9	4	3	LC	9.82	2	2	LC	–	–
Boloria chariclea	–	–	6.9	4	3	NT	9.82	2	2	NT	–	–
Oeneis norna	–	–	6.9	4	3	NT	9.82	2	2	NT	–	–
Leptidea sinapis	–	–	6.9	39	33	LC	8.83	26	24	LC	–	–
Lycaena virgaureae	–	–	6.85	35	30	LC	8.52	23	21	LC	–	–
Hipparchia volgensis	EE	–	6.7	9	7	LC	1	3	3	LC	–	–
Boloria napaea	–	–	6.63	11	9	LC	7.75	7	7	LC	–	–
Erebia pluto	EE	–	6.57	7	6	LC	7.06	5	5	LC	–	–
Agriades glandon	EE	–	6.55	8	7	LC	6.84	5	5	LC	–	–
Coenonympha leander	–	–	6.47	8	7	LC	12.95	3	3	LC	–	–
Coenonympha glycerion	–	–	6.37	32	26	LC	6.57	20	18	LC	–	–
Apatura ilia	–	–	6.34	34	28	LC	5.96	22	20	LC	–	–
Coenonympha arcania	–	–	6.25	35	30	LC	7.77	23	21	LC	–	–
Cupido argiades	–	–	6.25	33	28	LC	7.24	21	20	LC	–	–
Melitaea varia	EE	–	6.25	4	4	LC	4.48	3	3	LC	–	–
Satyrium spini	–	–	6.23	28	24	LC	7.44	17	16	LC	–	–
Anthocharis euphenoides	EE	–	6.17	5	4	LC	6.22	4	3	LC	–	–
Hipparchia fidia	–	–	6.17	5	4	LC	6.22	4	3	LC	–	–
Satyrus actaea	EE	–	6.17	5	4	LC	6.22	4	3	LC	–	–
Agriades orbitulus	–	–	6.13	10	8	LC	7.54	6	6	LC	–	–
Melitaea ornata	–	–	6.11	16	14	–	6.48	10	10	–	–	–
Carterocephalus palaemon	–	–	6.06	36	30	LC	7.8	23	22	LC	–	–
Erebia oeme	EE	–	6.03	18	16	LC	7.16	10	10	LC	–	–
Erebia embla	–	–	6	6	4	LC	8.12	4	3	LC	–	–
Pyrgus malvoides	EE	–	5.83	11	9	LC	6.16	8	7	LC	–	–
Erebia melampus	EE	–	5.77	6	5	LC	6.21	4	4	LC	–	–
Erebia tyndarus	EE	–	5.77	6	5	LC	6.21	4	4	LC	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Oeneis glacialis	EE	–	5.77	6	5	LC	6.21	4	4	LC	–	–
Satyrus ferula	–	–	5.75	15	13	LC	4.87	8	8	LC	–	–
Speyeria aglaja	–	–	5.67	39	33	LC	7.2	26	24	LC	–	–
Melitaea deione	–	–	5.67	6	5	LC	1	4	3	LC	–	–
Coenonympha gardetta	EE	–	5.5	7	6	LC	5.89	5	5	LC	–	–
Lysandra coridon	EE	–	5.46	30	26	LC	6.98	18	18	LC	–	–
Lasiommata megera	–	–	5.37	40	32	LC	6.83	27	23	LC	–	–
Melanargia larissa	–	–	5.37	9	8	LC	1	4	4	LC	–	–
Pyrgus malvae	–	–	5.31	35	30	LC	6.88	23	22	LC	–	–
Papilio machaon	–	–	5.17	40	32	LC	6.08	27	23	LC	–	–
Hipparchia syriaca	–	–	5.08	11	8	LC	7.52	5	4	LC	–	–
Lasiommata maera	–	–	4.92	36	29	LC	6.39	23	20	LC	–	–
Plebejus argus	–	–	4.88	38	32	LC	5.75	25	23	LC	–	–
Gegenes nostrodamus	–	–	4.84	9	7	LC	5.41	6	5	LC	–	–
Erebia ottomana	–	–	4.39	10	9	LC	5.69	5	5	LC	–	–
Argynnis pandora	–	–	4.34	22	16	LC	3.4	11	9	LC	–	–
Pyrgus carlinae	EE	–	4.3	4	4	LC	1	3	3	LC	–	–
Charaxes jasius	–	–	4.27	10	7	LC	1	7	5	LC	–	–
Erebia mnestra	EE	–	4.08	5	4	LC	4.48	3	3	LC	–	–
Erebia montana	EE	–	4.08	5	4	LC	4.48	3	3	LC	–	–
Erebia triarius	EE	–	4.08	12	10	LC	1	6	5	LC	–	–
Gonepteryx cleopatra	–	–	4.04	13	9	LC	1	9	6	LC	–	–
Brenthis daphne	–	–	4.01	30	25	LC	5.05	19	17	LC	–	–
Colias alfacariensis	–	–	3.99	28	23	LC	4.1	17	16	LC	–	–
Euchloe simplonia	EE	–	3.84	5	5	LC	1	3	3	LC	–	–
Leptotes pirithous	–	–	3.81	20	12	LC	1	10	7	LC	–	–
Pontia edusa	–	–	3.78	28	23	LC	4.2	18	16	LC	–	–
Lycaena candens	–	–	3.75	8	7	LC	1	3	3	LC	–	–
Carcharodus alceae	–	–	3.7	32	26	LC	3.3	20	18	LC	–	–
Araschnia levana	–	–	3.61	32	28	LC	4.29	23	22	LC	–	–
Polyommatus escheri	–	–	3.6	13	12	LC	2.34	7	7	LC	–	–
Argynnis paphia	–	–	3.56	39	33	LC	4.41	26	24	LC	–	–
Colias erate	–	–	3.47	13	11	LC	4.68	8	8	LC	–	–
Leptidea juvernica	–	–	3.44	34	29	–	4.28	23	22	–	–	–
Parnassius phoebus	–	–	3.31	7	5	NT	3.53	4	4	NT	–	–
Lycaena tityrus	–	–	3.3	34	28	LC	4.07	22	20	LC	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Favonius quercus	–	–	3.21	40	33	LC	2.65	27	24	LC	–	–
Callophrys rubi	–	–	2.77	39	33	LC	3.34	26	24	LC	–	–
Boloria dia	–	–	2.57	33	27	LC	2.53	21	19	LC	–	–
Issoria lathonia	–	–	2.52	37	31	LC	3.07	24	22	LC	–	–
Maniola jurtina	–	–	2.42	41	33	LC	2.89	27	24	LC	–	–
Coenonympha pamphilus	–	–	2.22	40	33	LC	2.62	27	24	LC	–	–
Polyommatus icarus	–	–	2.16	40	33	LC	2.54	27	24	LC	–	–
Zerynthia rumina	–	–	2.16	4	3	LC	1	3	2	LC	–	–
Danaus chrysippus	–	EoR	2.16	9	6	NA	1	7	5	NA	–	–
Pieris brassicae	–	–	2.14	42	33	LC	2.04	28	24	LC	–	–
Lampides boeticus	–	–	2.11	22	12	LC	1	10	7	LC	–	–
Aricia agestis	–	–	1.92	33	28	LC	2.19	23	21	LC	–	–
Colias hyale	–	–	1.46	31	26	LC	1.63	20	19	LC	–	–
Ochlodes sylvanus	–	–	1.33	38	32	LC	1.44	25	23	LC	–	–
Thymelicus lineola	–	–	1.28	39	33	LC	1.37	26	24	LC	–	–
Erebia gorgone	EE	–	1.28	3	3	LC	1	2	2	LC	–	–
Laeosopis roboris	EE	–	1.28	4	3	LC	1	3	2	LC	–	–
Colias phicomone	EE	–	1.13	8	7	NT	1	5	5	NT	–	–
Aglais io	–	–	1.08	38	32	LC	1.1	26	24	LC	–	–
Pararge aegeria	–	–	1.08	42	33	LC	1.1	28	24	LC	–	–
Polygonia c–album	–	–	1.08	39	33	LC	1.1	26	24	LC	–	–
Vanessa cardui	–	–	1.08	45	33	LC	1.1	28	24	LC	–	–
Aphantopus hyperantus	–	–	1.05	38	33	LC	1	25	24	LC	–	–
Aglais ichnusa	EE	–	1	2	2	LC	1	2	2	LC	–	–
Aglais urticae	–	–	1	39	33	LC	1	26	24	LC	–	–
Agriades pyrenaicus	EE	–	1	2	2	LC	1	2	2	LC	–	–
Anthocharis cardamines	–	–	1	40	33	LC	1	27	24	LC	–	–
Aricia cramera	–	–	1	4	2	LC	1	3	2	LC	–	–
Aricia montensis	–	–	1	3	1	LC	1	2	1	LC	–	–
Azanus jesous	–	EoR	1	1	1	–	1	1	1	–	–	–
Azanus ubaldus	–	EoR	1	3	1	NA	1	2	1	NA	–	–
Borbo borbonica	–	–	1	1	1	NA	1	1	1	NA	–	–
Cacyreus marshalli	–	–	1	16	12	NA	1	9	7	NA	–	–
Carcharodus stauderi	–	EoR	1	1	1	NA	1	1	1	NA	–	–
Carcharodus tripolinus	–	–	1	2	1	LC	1	2	1	LC	–	–
Celastrina argiolus	–	–	1	41	33	LC	1	28	24	LC	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Coenonympha corinna	EE	–	1	2	2	LC	1	2	2	LC	–	–
Coenonympha thyrsis	EE	–	1	1	1	LC	1	1	1	LC	–	Greece—Crete
Colias aurorina	–	–	1	2	2	LC	1	1	1	LC	–	–
Colias crocea	–	–	1	38	27	LC	1	24	20	LC	–	–
Colotis evagore	–	–	1	1	1	NA	1	1	1	NA	–	–
Cupido lorquinii	–	–	1	2	1	LC	1	2	1	LC	–	–
Danaus plexippus	–	EoR	1	4	1	NA	1	1	1	NA	–	–
Erebia aethiopella	EE	–	1	2	2	LC	1	2	2	LC	–	–
Erebia arvernensis	EE	–	1	5	5	–	1	3	3	–	–	–
Erebia cassioides	EE	–	1	2	2	LC	1	2	2	LC	–	–
Erebia euryale	–	–	1	23	20	LC	1	13	13	LC	–	–
Erebia hispania	EE	–	1	2	2	LC	1	2	2	LC	–	–
Erebia neoridas	EE	–	1	4	4	LC	1	3	3	LC	–	–
Erebia palarica	EE	–	1	1	1	LC	1	1	1	LC	–	Spain
Erebia rondoui	EE	–	1	2	2	LC	1	2	2	LC	–	–
Erebia sthennyo	EE	–	1	2	2	LC	1	2	2	LC	–	–
Erebia stiria	EE	–	1	4	4	LC	1	4	4	LC	–	–
Erebia zapateri	EE	–	1	1	1	LC	1	1	1	LC	–	Spain
Euchloe belemia	–	–	1	2	1	LC	1	2	1	LC	–	–
Euchloe crameri	–	–	1	5	4	LC	1	4	3	LC	–	–
Euchloe insularis	EE	–	1	2	2	LC	1	2	2	LC	–	–
Glaucopsyche melanops	–	–	1	4	3	LC	1	4	3	LC	–	–
Gonepteryx rhamni	–	–	1	39	33	LC	1	26	24	LC	–	–
Hipparchia aristaeus	EE	–	1	2	2	LC	1	2	2	LC	–	–
Hipparchia blachieri	EE	–	1	1	1	–	1	1	1	–	–	–
Hipparchia cretica	EE	–	1	1	1	LC	1	1	1	LC	–	Greece—Crete
Hipparchia leighebi	EE	–	1	1	1	NT	1	1	1	NT	–	Italy—Aeolian Islands
Hipparchia mersina	–	EoR	1	1	1	NA	1	1	1	NA	–	–
Hipparchia neapolitana	EE	–	1	1	1	LC	1	1	1	LC	–	Italy
Hipparchia neomiris	EE	–	1	2	2	LC	1	2	2	LC	–	–
Iolana debilitata	–	–	1	1	1	–	1	1	1	–	–	–
Iphiclides feisthamelii	–	–	1	4	3	–	1	3	2	–	–	–
Lasiommata paramegaera	EE	–	1	2	2	LC	1	2	2	LC	–	–
Leptidea reali	–	–	1	4	4	LC	1	3	3	LC	–	–
Lycaena bleusei	EE	–	1	2	1	LC	1	2	1	LC	–	–
Lycaena phlaeas	–	–	1	42	33	LC	1	28	24	LC	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Lysandra albicans	–	–	1	1	1	LC	1	1	1	LC	–	–
Lysandra caelestissima	EE	–	1	1	1	LC	1	1	1	LC	–	Spain
Lysandra hispana	EE	–	1	3	3	LC	1	3	3	LC	–	–
Maniola chia	EE	–	1	1	1	LC	1	1	1	LC	–	Greece—Chios
Maniola nurag	EE	–	1	1	1	LC	1	1	1	LC	–	Italy—Sardinia
Maniola telmessia	–	–	1	1	1	LC	1	1	1	LC	–	–
Melanargia arge	EE	–	1	1	1	LC	1	1	1	LC	II+IV	Italy
Melanargia galathea	–	–	1	30	25	LC	1	19	18	LC	–	–
Melanargia ines	–	–	1	2	1	LC	1	2	1	LC	–	–
Melanargia lachesis	EE	–	1	4	3	LC	1	3	2	LC	–	–
Melanargia occitanica	–	–	1	4	3	LC	1	4	3	LC	–	–
Melanargia pherusa	EE	–	1	1	1	LC	1	1	1	LC	–	Italy—Sicily
Melitaea celadussa	EE	–	1	6	5	–	1	4	3	–	–	–
Papilio hospiton	EE	–	1	2	2	LC	1	2	2	LC	II+IV	–
Pieris balcana	EE	–	1	10	9	LC	1	5	5	LC	–	–
Pieris napi	–	–	1	39	33	LC	1	26	24	LC	–	–
Pieris rapae	–	–	1	43	33	LC	1	28	24	LC	–	–
Plebejidea loewii	–	EoR	1	2	1	NA	1	1	1	NA	–	–
Plebejus bellieri	EE	–	1	2	2	LC	1	2	2	LC	–	–
Polyommatus celina	–	–	1	5	2	–	1	4	2	–	–	–
Polyommatus fabressei	EE	–	1	1	1	LC	1	1	1	LC	–	Spain
Polyommatus fulgens	EE	–	1	1	1	LC	1	1	1	LC	–	Spain
Polyommatus nivescens	EE	–	1	1	1	NT	1	1	1	NT	–	Spain
Polyommatus timfristos	EE	–	1	1	1	–	1	1	1	–	–	Greece
Polyommatus violetae	EE	–	1	1	1	VU	1	1	1	VU	–	Spain
Pontia daplidice	–	–	1	7	4	LC	1	5	3	LC	–	–
Pseudochazara anthelea	–	–	1	2	1	LC	1	2	1	LC	–	–
Pseudochazara graeca	EE	–	1	1	1	LC	1	1	1	LC	–	Greece
Pseudophilotes abencerragus	–	–	1	2	1	LC	1	2	1	LC	–	–
Pseudophilotes barbagiae	EE	–	1	1	1	LC	1	1	1	LC	–	Italy—Sardinia
Pseudophilotes panoptes	EE	–	1	2	1	NT	1	2	1	NT	–	–
Pyrgus foulquieri	EE	–	1	3	3	LC	1	3	3	LC	–	–
Pyronia bathseba	–	–	1	3	2	LC	1	3	2	LC	–	–
Pyronia cecilia	–	–	1	8	6	LC	1	6	5	LC	–	–
Satyrium esculi	–	–	1	5	4	LC	1	4	3	LC	–	–
Spialia rosae	EE	–	1	1	1	–	1	1	1	–	–	Spain

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Tarucus theophrastus	–	–	1	1	1	LC	1	1	1	LC	–	–
Thymelicus hyrax	–	–	1	2	1	LC	1	1	1	LC	–	–
Thymelicus sylvestris	–	–	1	36	30	LC	1	24	22	LC	–	–
Vanessa atalanta	–	–	1	45	33	LC	1	28	24	LC	–	–
Vanessa virginiensis	–	EoR	1	2	1	NA	1	2	1	NA	–	–
Zerynthia cassandra	EE	–	1	1	1	–	1	1	1	–	–	Italy
Zizeeria knysna	–	EoR	1	3	1	NA	1	2	1	NA	–	–
Erebia callias	–	EoR	–	1	–	–	–	–	–	–	–	–
Hypolimnas misippus	–	EoR	–	–	–	–	–	–	–	–	–	–
Oeneis ammon	–	EoR	–	1	–	–	–	–	–	–	–	–
Pseudochazara mercurius	–	EoR	–	1	–	–	–	–	–	–	–	–
Pieris wollastoni	EE	–	–	1	–	CR	–	–	–	CR	–	Madeira Islands
Gonepteryx maderensis	EE	–	–	1	–	EN	–	–	–	EN	–	Madeira Islands
Pararge xiphia	EE	–	–	1	–	EN	–	–	–	EN	–	Madeira Islands
Pieris cheiranthi	EE	–	–	1	–	EN	–	–	–	EN	–	Canary Islands
Cyclyrius webbianus	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Euchloe charlonia	–	EoR	–	1	–	LC	–	–	–	LC	–	–
Euchloe eversi	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Euchloe grancanariensis	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Euchloe hesperidum	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Glaucopsyche paphos	EE	–	–	1	–	LC	–	1	–	LC	–	Cyprus
Hipparchia azorina	EE	–	–	1	–	LC	–	–	–	LC	–	Azores
Hipparchia cypriensis	EE	–	–	1	–	LC	–	1	–	LC	–	Cyprus
Hipparchia gomera	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Hipparchia maderensis	EE	–	–	1	–	LC	–	–	–	LC	–	Madeira Islands
Hipparchia miguelensis	EE	–	–	1	–	LC	–	–	–	LC	–	Azores
Hipparchia tamadabae	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Hipparchia wyssii	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Maniola cypricola	EE	–	–	1	–	LC	–	1	–	LC	–	Cyprus
Pararge xiphioides	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Thymelicus christi	EE	–	–	1	–	LC	–	–	–	LC	–	Canary Islands
Vanessa vulcania	EE	–	–	2	–	LC	–	–	–	LC	–	–
Boloria selenis	–	–	–	1	–	LC	–	–	–	NE	–	–
Erebia discoidalis	–	–	–	1	–	LC	–	–	–	NE	–	–
Hipparchia autonoe	–	–	–	1	–	LC	–	–	–	NE	–	–
Lysandra corydonius	–	–	–	1	–	LC	–	–	–	NE	–	–

Table 3 (continued)

Species name	EE	EoR	wsRLVEur	#CoEur	#CoRLEur	RLCEur	wsRLVEU	#CoEU	#CoRLEU	RLCEU	HD	Endemic
Boloria alaskensis	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Boloria angarensis	–	–	–	1	–	NA	–	–	–	NA	–	–
Boloria oscarus	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Boloria tritonia	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Callophrys chalybeitincta	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Callophrys suaveola	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Catopsilia florella	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Cigaritis acamas	–	EoR	–	1	–	NA	–	1	–	NA	–	–
Coenonympha amaryllis	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Erebia cyclopius	–	EoR	v	1	–	NA	–	–	–	NA	–	–
Erebia dabanensis	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Erebia edda	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Erebia fasciata	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Erebia jeniseiensis	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Erebia rossii	–	–	–	1	–	NA	–	–	–	NA	–	–
Glabroculus cyane	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Hyponephele huebneri	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Issoria eugenia	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Lasiommata deidamia	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Luthrodes galba	–	EoR	–	1	–	NA	–	1	–	NA	–	–
Lycaena dimorpha	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Oeneis magna	–	EoR	–	1	–	NA	v	v	–	NA	v	–
Oeneis melissa	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Oeneis polixenes	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Praephilotes anthracias	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Tongeia fischeri	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Zegris pyrothoe	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Zerynthia caucasica	–	EoR	–	1	–	NA	–	–	–	NA	–	–
Gonepteryx cleobule	EE	–	–	1	–	VU	–	–	–	VU	–	Canary Islands
Hipparchia bacchus	EE	–	–	1	–	VU	–	–	–	VU	–	Canary Islands
Hipparchia tilosi	EE	–	–	1	–	VU	–	–	–	VU	–	Canary Islands

[a]The species is now considered as being of Least Concern in the Mediterranean region (Numa et al. 2016)

to publish regional Red Lists as a data paper, preferentially in an open access journal.

The weighted Red List value must be interpreted with care since not all countries have (up-to-date) national Red Lists (e.g. Russia, Portugal). Especially large countries such as Russia could have a big impact on the wsRLV since the Red List status is weighted using the area of the country as was done in the European Red List of butterflies (van Swaay et al. 2010). When such large countries publish a new Red List, it might change the wsRLV considerably. When the area as such is used as weighting factor, for *Colias myrmidone*, for example, if it would be classified as LC, NT, VU, EN or CR in Russia, its wsRLV would change from 78.3 without Russia, to 25.8, 38.6, 45.3, 58.7, 78.8, respectively with Russia. By using the square root of the country's area, however, the wsRLVs would be 53.3, 59.4, 62.7, 69.1, 78.8, respectively. Another example is *Oeneis tarpeia* which occurred marginally in the Ukraine and is more widespread in Russia. Its highest possible wsRLV (100) is explained by the fact that only Ukraine has a Red List status for the species (regionally extinct) while Russia has none. If Russia were to classify it as Least Concern, its wsRLV would drop from 100 to 28.77.

Countries and species of European conservation concern

Countries with the highest mean Red List Value are under a very high anthropogenic pressure (e.g. Czech Republic—Konvička et al. 2006) and/or have among the highest nitrogen deposition values in Europe (Dise et al. 2011; e.g. the Netherlands—WallisDeVries and van Swaay 2017; Belgium—Maes and Van Dyck 2001; Maes et al. 2012). Large Mediterranean countries such as Italy (Bonelli et al. 2018) and Spain, in contrast, have the lowest proportion of threatened species. In Spain, this is mainly due to the fact that only 14 species were assessed against the IUCN Red List criteria of which six were considered as threatened (Verdú and Galante 2009; Verdú et al. 2011). On the other hand, in Italy where almost 98% of the species were assessed, the proportion of threatened species is also low. This is due to the low population density and to the ample availability of high quality habitat for butterflies (e.g. the Italian alpine region is not impacted by high anthropogenic pressures and hosts more than 150 species—Bonelli et al. 2018).

The weighted Red List value showed some mismatches between the European Red List category and the threat status in the different European countries (Brito et al. 2010). 128 species have a wsRLV ≥ 20 of which 55 (43%) are considered as threatened (Critically Endangered, Endangered or Vulnerable) or Near Threatened on the European Red list. On the other hand, 60 (47%) of these species were classified in the category Least Concern on the European Red list. Nine species that are endemic to Europe with a relatively high wsRLV (≥ 20) are considered of Least Concern on the European Red List (in decreasing order of wsRLV): *Pseudophilotes baton, Erebia rhodopensis, Hipparchia christenseni, Satyrus virbius, Carcharodus baeticus, Erebia orientalis, Kretania hesperica, Kretania psylorita, Euchloe bazae* and *Zerynthia cretica*. This wsRLV, in addition to the Habitats Directive, the European Red List of butterflies and the endemism of species (SPECs, i.e. Species of European Conservation Concern—van Swaay et al. 2011), can help to determine for which butterflies conservation action should be undertaken. It can, for example, indicate for which (sub-) national or European species action plans should be compiled or for which species more research is needed to protect them more adequately. The ecology of the species with a high weighted Red List value that are also on the Habitats Directive and the management measures needed for their conservation are discussed in van Swaay et al. (2012). Some of the species with high weighted Red List values have been relatively well-studied recently: *Colias myrmidone* (e.g. Dolek et al. 2005; Konvička et al. 2008; Szentirmai et al. 2014; Sielezniew et al. 2019), *Pseudochazara cingovskii* (e.g. Verovnik et al. 2013), *Agriades zullichi* and *Polyommatus violetae* (e.g. Munguira et al. 2017), *Coenonympha hero* (e.g. Cassel-Lundhagen et al. 2008; Tiitsaar et al. 2016; Sielezniew and Nowicki 2017), *Coenonympha oedippus* (e.g. Čelik et al. 2009, 2015) and *Lycaena helle* (e.g. Habel et al. 2010; Nabielec and Nowicki 2015). For others, such as *Erebia neleus* (e.g. Schmitt et al. 2016) and *Polyommatus orphicus* (Vishnevskaya et al. 2016), research is mainly focusing on genetics in order to determine the species' taxonomic status.

On the basis of our study, we can determine nine species that are endemic to Europe, that are not on the Habitats Directive, that are classified as critically endangered, endangered or vulnerable (or were not assessed or data deficient) on the European Red List of butterflies, that have a wsRLV ≥ 30: *Pseudochazara orestes, Agriades zullichi, Polyommatus humedasae, Pyrgus cirsii, Polyommatus orphicus, Pseudochazara amymone* (Verovnik et al. 2014), *Pseudochazara cingovskii, Pseudochazara euxina* and *Euchloe bazae* (Tables 2, 3). All of these species were also mentioned as Species of European Conservation Concern in a follow-up exercise of the Red List of European butterflies (van Swaay et al. 2011) and are most in need of ecological research and/or monitoring for their conservation in Europe.

Due to a mismatch between the European Red List of butterflies and the species on the Annexes of the Habitats Directive, some authors suggested regular updating of the Habitats Directive (Cardoso 2012; Hochkirch et al. 2013). Maes et al. (2013), however, argued that this would allow member states to weaken the Habitats Directive legislation, which would be counterproductive. The complementary use

of different approaches to determine conservation priorities (Habitats Directive, the IUCN European Red List of butterflies, Species of European Conservation Concern, this exercise) for butterflies is, in our opinion, a better approach.

Conservation actions for species with a high wsRLV can be taken both on the (sub-) national and on the continental scale. National legislations could protect sites with threatened butterfly species, for example, in Natura 2000 sites and other nature reserves. Management and restoration measures can help to preserve or create suitable ecological conditions for butterflies (van Swaay et al. 2012). Other measures such as (re)connecting sites with threatened species and/or reintroductions of regionally extinct species can also be taken on the national level (Kuussaari et al. 2015). On a broader, continental scale, actions to reduce nitrogen deposition (Pöyry et al. 2017; WallisDeVries and van Swaay 2017) and/or the effect of climate change (Hill et al. 2002; Devictor et al. 2012) could help to preserve and protect threatened butterflies. For island endemics, measures to prevent the introduction of invasive species are important in addition to habitat conservation measures. Finally, creating a Natura 2000 network beyond national borders could help the exchange of individuals between neighbouring countries (Trochet and Schmeller 2013) and could enable species to track climate change-induced distribution shifts (Settele et al. 2008).

Improving national Red List assessments

Although Red Lists were not explicitly designed to be used in setting conservation priorities, many national and international conservation organisations and/or governmental institutions use them to prioritise actions for threatened species (Rodrigues et al. 2006). The availability of both European and national Red Lists is, therefore, of paramount importance for butterfly conservation. We encourage countries or regions without, or with an outdated Red List, to compile one, preferably using IUCN criteria so that Red Lists become more easily comparable among countries and species (Miller et al. 2007; Collen and Böhm 2012). If a given region is under-surveyed, citizen science can help to augment distribution data (e.g. through tourists that record butterflies while on holidays and enter their data in, for example, Observado or iNaturalist—Maes et al. 2015). This would make it possible to estimate the Area of Occupancy and Extent of Occurrence (the two main figures needed for criterion B of the IUCN criteria—Bland et al. 2016) much more accurately. With the list length method (a systematic list-based monitoring—Roberts et al. 2007), we can also calculate European distribution trends more easily. To collect trend data, establishing national or regional butterfly monitoring schemes in countries without such a scheme at present (as in some of the Mediterranean and Eastern European countries—van Swaay et al. 2016), could be very helpful. Butterfly Conservation Europe and its partners are actively working on extending monitoring schemes to new countries and expand the monitoring in existing countries. One of the initiatives is the eBMS (http://www.butterfly-monitoring.net), in which 12 Butterfly monitoring schemes are already participating. This is also important, since population trends detect declines more rapidly than distribution trends (van Strien et al. 2011). This would allow the calculation of more reliable trends, one of the criteria for regional IUCN Red List assessments (IUCN 2012). All these new developments will make it possible to make use of quantitative data instead of expert judgements and will be a huge step forward for the compilation of the next European Red List of butterflies. Similarly, the compilation of national species distribution data into a European database (cf. LepiDiv) would facilitate the calculation of the continental range of species (criterion B for the IUCN Red List assessment).

If Red Lists are updated regularly, e.g. every 10 years as suggested by the IUCN (cf. IUCN 2013) it would even become possible to make a Red List Index for butterflies at the global or continental (Butchart et al. 2005; Lewis and Senior 2011), next to the (sub-) national scales (e.g. Juslén et al. 2013). We also recommend the publication of the threat status of all species present in a country, not only those that are threatened. This excludes the problem of not knowing whether a species is either absent from the country, is not threatened, or was not assessed.

The use of regional IUCN criteria in smaller countries or regions (e.g. Flanders, northern Belgium—Maes et al. 2012) could lead to the classification of a larger number of species in a relatively high threat category because of the smaller absolute area of occupancy or extent of occurrence (IUCN criterion B) compared with large countries. This does, however, not seem to be the case (Fig. 3; Pearson correlation = − 0.275, p = 0.121), possibly because of the downgrading option in regional Red List assessments (IUCN 2003).

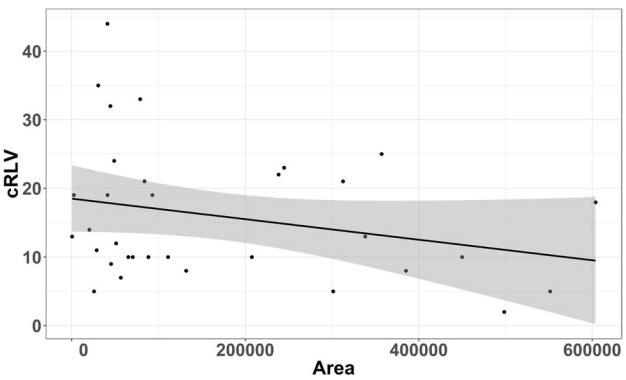

Fig. 3 Correlation between the area (sqrtArea) of a country (*x*-axis) and the mean Red List Value (cRLV—*y*-axis)

A final recommendation to improve the use of Red List assessments is to publish the distributional data at the highest possible resolution together with the criteria used to compile the national Red List on an open access platform (e.g. GBIF). National or local data are not always known about or accessible to global Red List assessors (Rodrigues et al. 2006) and open access publications could greatly help supra-national Red List comparisons or compilations (Numa et al. 2016).

In conclusion, the database developed together with this paper, i.e. an integrated database with national species inventories and all currently available national Red Lists, allowed us to prioritise conservation actions for European butterflies, in addition to existing tools such as the Habitats Directive, the Red List of European butterflies and information on endemism. Regular updates of this database will allow policy makers and butterfly conservationists to continuously estimate Red List Values for all European butterflies.

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Data availability The basic tables that were used for analysis are available on GitHub (https://github.com/inbo/red-lists-european-butterflies-checklist). The database will be updated regularly (e.g. when a country publishes a new Red List of butterflies) and a new ranking of species (Table 2) can be obtained by running the R Markdown script made available on the same location in GBIF.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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