

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/329117670>

Notes on the geographical variation of *Hipparchia autonoe* (Insecta: Nymphalidae: Satyrinae) with description of a new subspecies from Qinghai (China). In book: Hartmann M, Barclay...

Chapter · November 2018

CITATIONS

0

READS

37

3 authors, including:



Valerio Sbordoni

University of Rome Tor Vergata

313 PUBLICATIONS 2,599 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Biodiversity networking [View project](#)



Population genetics for fisheries and aquaculture [View project](#)

Notes on the geographical variation of *Hipparchia autonoe* (Insecta: Nymphalidae: Satyrinae) with description of a new subspecies from Qinghai (China)

VALERIO SBORDONI, GIAN CRISTOFORO BOZANO & DONATELLA CESARONI

Summary

Hipparchia autonoe (Esper, 1783) is a Palearctic species showing a wide-ranging geographical distribution from the Caucasus to Tibet across the south of Siberia and Mongolia to the Far East of Asia and the north of China, and a considerable degree of phenotypic variation. This note focuses on the area that includes the highlands of Qinghai, Tibet and Gansu, where different phenotypes and races fly at a relatively short distance from one another, demanding both a taxonomic revision and a biogeographical interpretation.

In particular, we describe *H. autonoe arcellae* n. ssp. from Qinghai, and resurrect the taxon *H. a. extrema* as a valid subspecies, formerly synonymized by KUDRNA (1977) with the nominotypical subspecies. Both its distinctive wing pattern and male genitalia morphometrics support this interpretation.

From a biogeographical point of view, processes of vicariance and dispersal, similar to those reported on plants, could have affected evolutionary divergence of populations in refugia of the Qinghai-Gansu-Sichuan area followed by a recent demographic spread. The relatively greater uniformity of the Eurasian populations is also hypothesized to be the result of a quite recent expansion.

Zusammenfassung

Hipparchia autonoe (Esper, 1783) ist eine weit verbreitete paläarktische Art mit einem Areal vom Kaukasus bis Tibet, Südsibirien und die Mongolei bis zum Fernen Osten Asiens und dem nördlichen China, mit einer beträchtlichen phänotypischen Variationsbreite. Diese Arbeit beschränkt sich auf ein Gebiet, welches das Hochland von Qinghai, Tibet und Gansu umfasst. Hier kommen verschiedene Phänotypen und Unterarten in kurzer Entfernung voneinander vor, was eine taxonomische Revision und eine biogeografische Interpretation erforderlich machte.

Im Einzelnen wird hier die Unterart *H. autonoe arcellae* n. ssp. aus Qinghai neu beschrieben und die Unterart *H. a. extrema* revalidiert. Letztere wurde früher von KUDRNA (1977) mit der Nominatform synonymisiert. Beide Unterarten sind deutlich durch die Flügelmuster und den Bau der männlichen Genitalien von der Nominatform zu unterscheiden.

Aus biogeografischer Sicht ist der Prozess der Arttrennung und Ausbreitung ähnlich dem der bei Pflanzen festgestellten Abläufe. Einer divergierenden Entwicklung von Populationen im Rückzugsareal Qinghai-Gansu-Sichuan folgte eine rezente Auffächerung in verschiedene Taxa. Die relativ größere Einformigkeit der eurasischen Populationen wird als ein Ergebnis der rezenten Ausbreitung gedeutet.

Key words: Lepidoptera, *Hipparchia*, new subspecies, geographic variation, China

Introduction

Within the genus *Hipparchia*, *H. autonoe* (Esper, 1783) is the species exhibiting the most extensive geographic distribution. Its distribution range extends more or less continuously from the Caucasus to Tibet through the south of Siberia and Mongolia to Far East Asia and north of China. Several names have been proposed to characterize taxonomically distinct populations and subspecies.

However, the diagnostic characters and the geographical delimitation of these taxa were not always clear. In a review of the genus, KUDRNA (1977) inferred geographic variation of *H. autonoe* (Esper, 1783) as a long transcontinental cline ranging from Eastern Europe, through southern Siberia and Mongolia, to the Far East of Asia and the north of China. Consistently with this observation, this author synonymized most of the names of taxa, emphasizing that the significant individual variability obscured geographical variation of this species. Kudrna recognized as distinct subspecies only a few peripheral isolates such as *H. celaeno* (Leech, 1892) in Tibet, *H. maxima* (Bang-Haas, 1933) in Gansu, and *H. zezutonis* (Seok, 1934) in the island of Cheju-do (South Korea), synonymizing all other forms with the nominotypical subspecies.

During a trip, many years ago to Qinghai and Gansu, G. C. Bozano and V. Sbordoni collected a series of well-characterized *H. autonoe* specimens showing a high degree of coherent geographic variation. The material was brought to Rome for genetic and morphological analyses. A statistical evaluation of the different population samples was carried out through male genitalia. After many years, we decided to return to these data, encouraged by the need to solve taxonomic problems while

preparing a forthcoming issue on *Hipparchia* in the series "Guide to the Butterflies of Palearctic Region" edited by G. C. Bozano, which involved the authors of this note along with John Coutsis (SBORDONI et al. 2018).

In this paper, therefore, we describe a new ssp. and discuss its relationships with the other populations of *H. autonoe* occurring north of Himalaya, in the highlands of Gansu and the Tibetan-Qinghai plateau.

Material and Methods

The material examined is deposited in the following private and public collections:

- EGGE - Coll. E. Gallo, Genova, Italy
- GCBMI - Coll. G. C. Bozano, Milan, Italy
- MZUF - "La Specola" Museum of Natural History of the University of Florence, Florence, Italy
- VSRM - Coll. V. Sbordoni, Rome, Italy
- WEHE - Coll. W. Eckweiler, Frankfurt, Germany

Morphological measurements of male genitalia: Male genital structure were extracted and prepared, according to standard methodologies. 25 individuals from 8 sampling localities (Table I) were scored using a binocular microscope fitted with a tracking device. Four drawings were made of each male genital structure (20 x magnification), two from each side. For each drawing, 11 measurements (Fig. 1) were taken with a bow compass. As variables for the morphometric individual

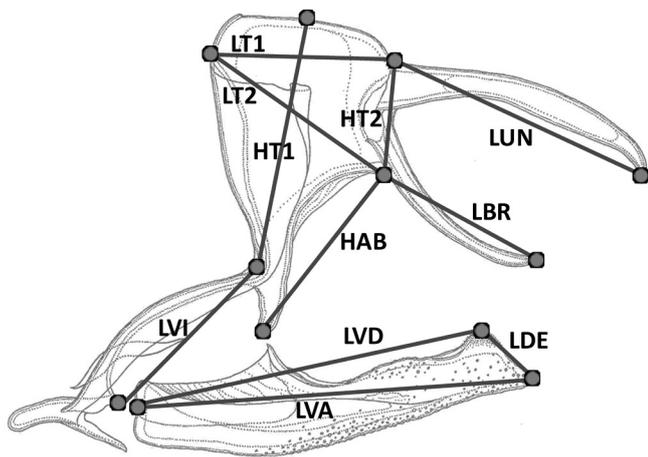


Figure 1: Morphometric measurements taken on male genitalia (redrawn from CESARONI et al. 1994)

profile, we utilized the means calculated on the four replicates. **Statistical methods:** Morphometric measurements were subjected to canonical variate analysis (CVA) using the program PAST (HAMMER et al. 2001). The results were used to determine which variables maximally contribute to distinction of the taxa.

Results

Hipparchia autonoe arcellae n. ssp.

Plate A

Holotype: ♂ China, Qinghai, Haixi Mongolian-Tibetan Autonomous Prefecture, Burhan Budai Shan, Balong, m 3300 - 3700, Dulan County, at roughly 35°41'38"N, 97°15'55"E, 6-9.VIII.1990, leg. V.Sbordoni, deposited in the V.Sbordoni collection (VSRM code of the Global Registry of Biodiversity Repositories).

Paratypes: China, Qinghai, Burhan Budai Shan, Balong, m 3300 - 3700, 6-9.VIII.1990, 4 ♂♂ and 14 ♀♀ leg. et coll. G. C. Bozano, (Milano), 5 ♂♂ and 12 ♀♀ leg. et coll. V.Sbordoni; China, Qinghai, Burhan Budai Shan, Eastern Mountains, m 3700 - 4000, 6-9.VIII.1990, 3 ♂♂ and 1 ♀ leg. et coll. V.Sbordoni; China, Qinghai, Burhan Budai Shan, Southern Mountains, m 4000-4200, 6-9.VIII.1990, 2 ♂♂ leg. et coll. V.Sbordoni. China, Qinghai, Burhan Budai Shan, Balong m 3500, 6-8.VIII.1990, 7 ♂♂ and 11 ♀♀ leg. et coll. E.Gallo. China, Qinghai, Eastern Qilian Shan, North of Chaka Lake, m 3500-3700, 2 ♂♂ and 2 ♀♀ leg. et coll. V. Sbordoni; Chaka Nun, m 3400, 9.VII.1994, leg. J. Klir, coll. V. Sbordoni; China, Qinghai, Dulan, m3500, 1 ♂ and 1 ♀ leg. A. Karbalaye, coll. V. Sbordoni; China, Qinghai, Qinghai Nanshan, Dashuiqiao vic. m 3500, 27.VII.1990, 1 ♀ leg. et coll. E. Gallo. China, Qinghai Nanshan, Chaka Lake vic. m 3600, 11.VIII.1990, 1 ♀ leg. et coll. E. Gallo. China, Qinghai Qaidam Angutan, 3500 m, 22. VII. 1987, 1 ♂, 1 ♀ leg. Koiwaya, coll. W. Eckweiler. China Qinghai, Dulan Mts 3550m, Tibetan Hospital, Borne 456, 4 ♂♂ and 2 ♀♀ leg. J. C. Lelong, coll. W. Eckweiler.

Etymology: The new species is named after Laura Arcelli Bozano, the wife of the second author.

Description: Male: size 44-48 mm. Upperside: ground colour variable from light to dark brown; light postdiscal band wide on both wings; forewing black ocelli large, hindwing ocellum at anal angle often present. Underside: ground colour light brown, lighter than in any other subspecies of *H. autonoe*; under forewing dark lines at middle and end of cell vestigial or absent; under hindwing veins strongly lined with white, postdiscal band always well developed, but narrower than on upper hindwing. Female: size 47-55 mm. Upperside: same as the male, but ground colour lighter and light postdiscal band wider. Underside: same as the male.

Male genitalia: (Plate A) valva overall slender and shorter than in nominotypical *autonoe*, with distal extremity shorter. Jullien organ: as in nominotypical *autonoe*.

Diagnosis: Notwithstanding the strong individual variability, usual in all populations of *H. autonoe*, the new subspecies can be easily distinguished by the whitish postdiscal band that it constantly wider than in any other *autonoe* population. Additional diagnostic characters are the upperside light ground colour, especially evident in the females, and the prominent white lining of the hindwing underside.

Habitat: The new subspecies was found from the end of July to the first decade of August in some localities of Qinghai where this butterfly appears to be widespread. Most of the samples were recorded in the northern slopes of the Burhan Budai Shan, in an area of smooth valleys and steep hills at altitudes from 3500 to 4200 m, covered with grass and sparse bushes (Plate B). The whole area is characterized by a subalpine semi-arid climate, with long very cold winters and warm summers.

At the lower altitude of 3300-3700m, the majority of *arcellae* specimens were females and most of them were worn, suggesting that the flight period begins at the end of June. A few, fresher individuals were sampled at higher locations.

Other butterflies flying in the area included *Parnassius szechenyii*, *P. nomion koiwayai*, *P. epaphus* cfr. *tsaidamensis*, *Baltia butleri*, *Pontia chloridice*, *P. callidice*, *Colias wanda*, *Melitaea arcesia*, *Argynnis clara*, *Boloria sifanica*, *Coenonympha amaryllis*, *C. semenovi*, *Paroeneis pumilus buddha*, *Oeneis buddha kincli*, *Polyommatus* cfr. *erotides*, *Plebejus* cfr. *qinghaiensis*, *Albulina orbitulus*.

Distribution: The range of *Hipparchia autonoe arcellae* includes a wide area of Qinghai, extending from Xining to 400 km Eastwards and includes Qilian Shan, Burhan Budai Shan and other mountain ranges of this region.

Geographical variation of *H. autonoe* in China

As already outlined, Kudrna considered most of the *H. autonoe* populations to belong to the same nominal subspecies, showing a great extent of individual variation. However, if we take a closer look at the geographic variation, especially in Central China area, we are able to detect constant and discriminating characters of wing pattern and/or male genitalia, which allow to distinguish between geographically different groups of populations. (Plate A)

Individuals belonging to typical forms of *H. a. maxima*, *H. a. celaeno* and now the new subspecies *H. a. arcellae* are easily

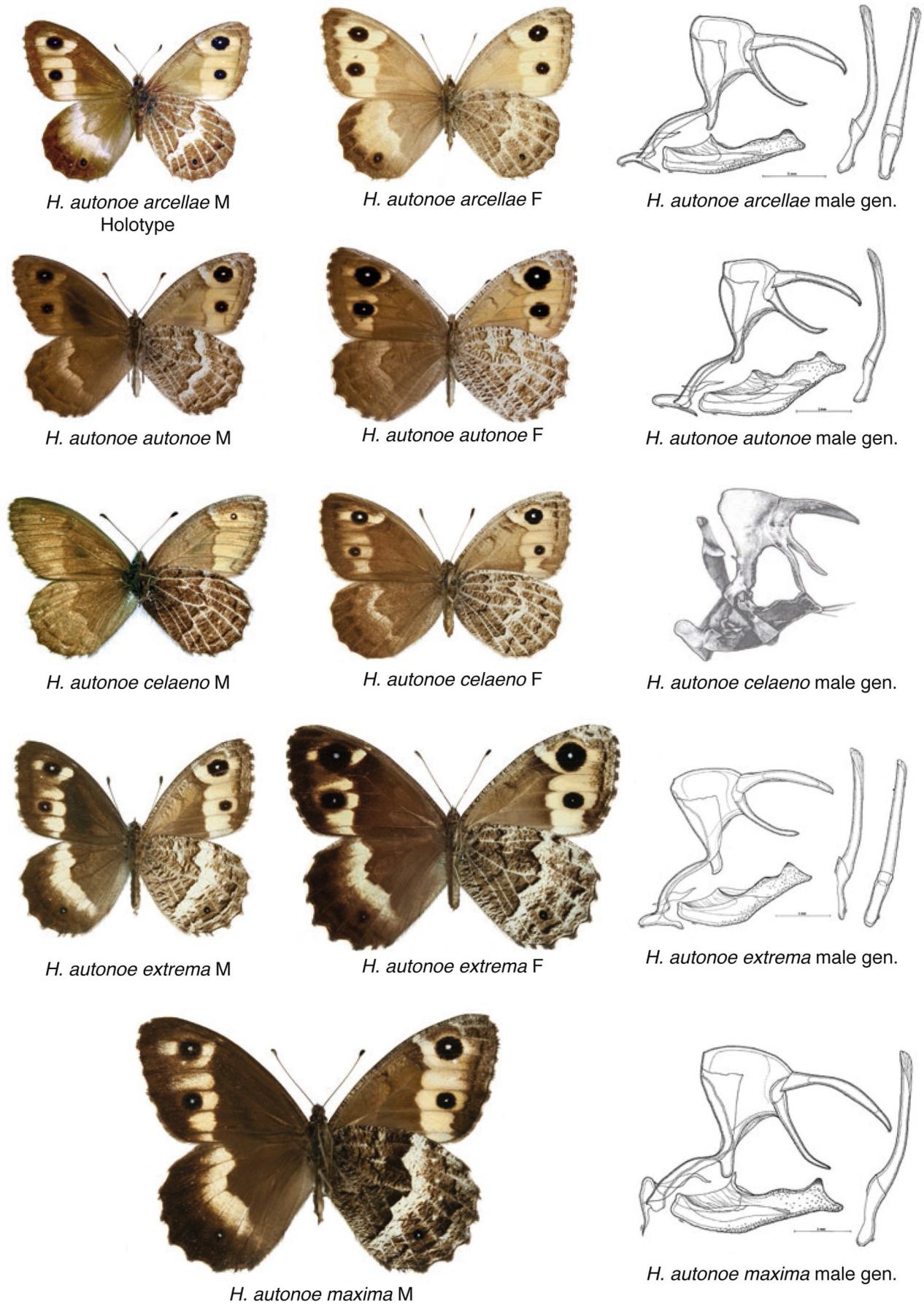


Figure 2: Each row illustrates a single subspecies of *H. autonoe*: males (recto/verso), females (recto/verso), and male genitalia drawings. First element of the first row: *H. autonoe arcellae* n. ssp., holotype ♂ from China, Qinghai, Haixi Mongolian-Tibetan Autonomous Prefecture, Burhan Budai Shan, Balong, m 3300-3700.



Figure 3: Balong area in the Burhan Budai Shan, the type locality of *Hipparchia autonoe arcellae* n. ssp.

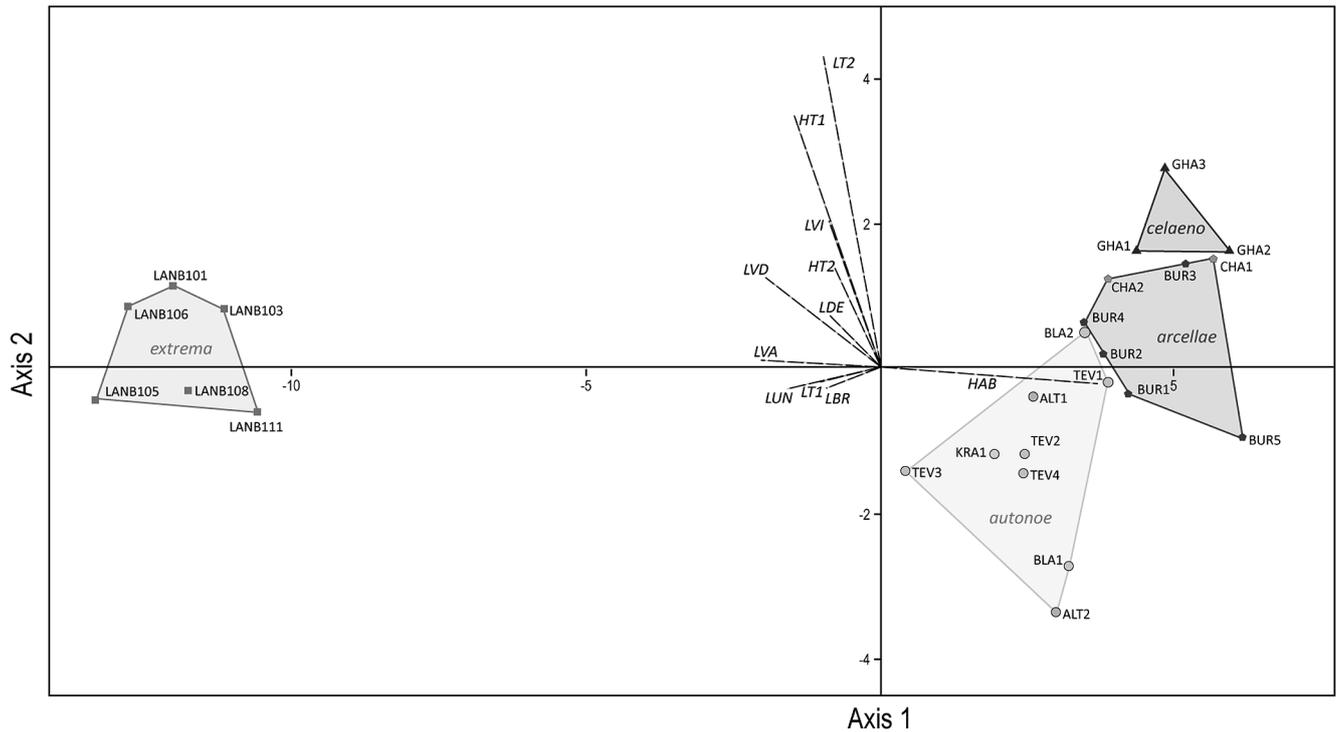


Figure 4: Canonical variate analysis performed on measurements of male genitalia. Shapes encompass individuals within the same subspecies.

distinguishable from each other by wing pattern, but other samples from Gansu also appeared phenotypically different from Russian and Mongolian *H. autonoe autonoe* samples, suggesting the need of a closer look into the male genitalia. Results from a Canonical Variate Analysis (Discriminant Analysis) performed on the measured male genitalia from 25 specimens from eight localities are illustrated in Figure 2. The cumulative proportion of total dispersion for the first and second

canonical variable was 0.99. This analysis showed that the 4 a priori established groups (subspecies samples) were distinguished from each other with 88% of correctly classified samples. Major loading on Axis 1 was from HAB (0.063) followed by LVA (-0.035) and LVD (-0.033). The first axis indicated a definitely superior distinctness of the LANB population from all others based on size and shape of male genitalia.

Discussion

Despite the extensive geographic distribution of *H. autonoe*, with populations from the Caucasus in Eastern Europe to Amur in Far Eastern Asia and southwards to Sichuan, a strong homogeneity was found in their male genitalia. The eight studied populations belonged to four different subspecies, mainly separated from each other based on wing patterns. Only specimens from Lanzhou (LANB, Gansu, China) showed distinctive characters in morphometric measurements of male genitalia. Lanzhou is located within the area from which the subspecies *H. autonoe extrema* (Alpheraky, 1889) was originally described. The difference between *H. a. extrema* (LANB) and other examined subspecies is mainly its larger global size of male genitalia, greater distance between junction tegument-brachium and end of the apex angularis (HAB) and longer valve (LVA, LVD).

Hence, *Hipparchia autonoe* occurs in this area of China with four very distinct forms that seem to have a mostly allopatric distribution, but with small overlapping zones (Plate B).

One of these locations is Huangyuan where at least one individual (female) with typically *arcellae* phenotype and one male with very contrasting *extrema*-like color were observed: these data could suggest a certain degree of admixture.

Another unusual situation appears to exist in the surroundings of Xiahe / Labrang Monastery where a small series of individuals, dark brown, similar to ssp. *celaeno* of Tibet, has recently been added to a small sample of individuals with *extrema* phenotype. Unfortunately, the collecting data are not georeferenced, and we cannot know how far the two collection sites are from one another, and if there are differences in habitat.

However, samples and sampling sites are still scanty. They will probably increase in the future, to clarify the occurrence and the extent of any hybrid zone or overlapping areas.

The presence of distinct geographic races in a relatively small area, opposed to the relative phenotypic homogeneity of the *H. autonoe* populations in the rest of its vast range raises some questions about the evolutionary significance of this variation. A first hypothesis refers to a general aptitude for phenotypic

change correlated with the characteristics of the present climate and habitat, even if to a lower degree, as has been suggested for other species of *Hipparchia* (DENNIS & SHREEVE 1989). The extent to which wing morphology is an expression of wing pattern related to the environment, reflecting a wide range of variation and/or phenotypic plasticity, needs to be explored.

A second hypothesis addresses the history of these butterflies and their alleged confinement to refugia during the last critical phase of the Pleistocene, followed by subsequent geographical expansion in the Holocene (LÓPEZ-PUJOL et al. 2011).

Unfortunately, the few available mtDNA sequence data useful for a phylogeographic approach are limited to South Korean and some Mongolian populations, and do not include the populations under discussion (CHO et al. 2011).

Recent studies of molecular phylogeography of conifers of the genera *Abies* and *Cupressus* (WANG et al. 2011, XU et al. 2010) indicate that in the mountain areas of Gansu and Shaanxi some taxa have experienced, during preglacial and glacial periods, confining conditions and isolation in refugia. This would explain the high intra-population variability and the genetic diversity of geographically close populations. The study of genetic markers has also highlighted complex hybridization and introgressive phenomena, which, while clarifying the role of evolutionary mechanisms, do not facilitate delimitation of species at the taxonomic level.

On the other hand, many species of predominantly steppe plants including various Berberidaceae, *Astragalus* etc. seem to have originated in the Qinghai-Tibetan Plateau and subsequently spread to Europe across Mongolia, Siberia and Central Asia. This phenomenon has been reported as "Out of the Qinghai-Tibet Plateau" (ZHANG et al. 2007, ZHANG et al. 2009, JIA et al. 2012).

Processes of vicariance and dispersal, as reported for plants, could have affected other taxa such as butterflies and explain the high morphological diversity and the small-scale geographical variation of *Hipparchia autonoe* in Qinghai, Gansu and N Sichuan. According to this hypothesis, the great uniformity of the Eurasian populations is likely to be the result of their quite recent expansion.

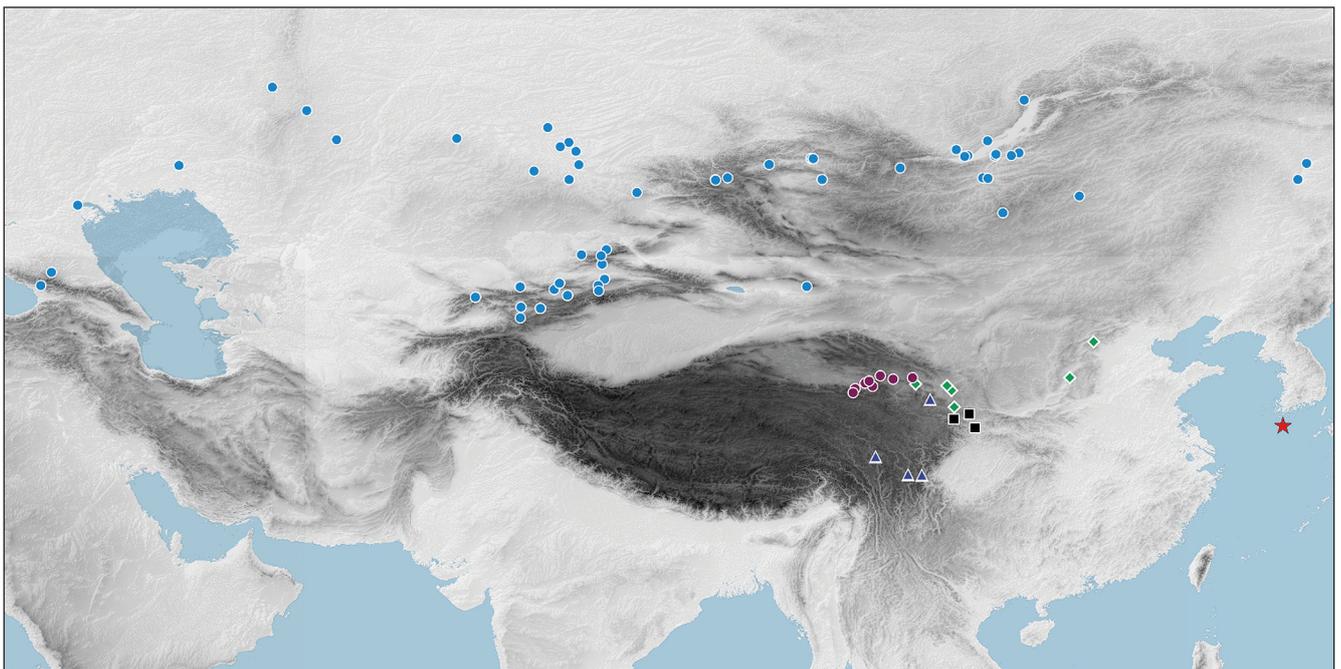


Figure 5: Geographic range of the *H. autonoe* subspecies. Symbols legend: *H. autonoe autonoe*, light blue circles; *H. a. arcellae* purple circles; *H. a. celaeno* blue triangles; *H. a. extrema*, green diamonds; *H. a. maxima*, black squares; *H. a. zezotonis*, red star.

Acknowledgements

We are indebted to John G. Coutsis for the genitalia drawings used in this paper and to Dr. Marco Lucarelli for measuring male genitalia used for morphometric analyses. We are grateful to Dr. Stefano De Felici for his help in map drawings, and to Dr. Luca Bartolozzi, Filippo Fabiano and Saulo Bambi ("La Specola" Museum of Natural History of the University of Florence) for providing photographs of a historical specimen of *H. autonoe cелаeno*. We warmly thank Dr. Enrico Gallo who participated with the senior authors in the early Qinghai expedition, as well as Dr. Wolfgang Eckweiler; both provided additional specimens of the new subspecies for the description and the type series.

References

- CESARONI, D.; M. LUCARELLI, P. ALLORI, F. RUSSO & V. SBORDONI (1994): Patterns of evolution and multidimensional systematics in graylings (Lepidoptera: *Hipparchia*). - Biological Journal of the Linnean Society **52** (2): 101-119.
- CHO, Y.; D. CHOI, Y. HAN & S. NAM (2011): Conservation of *Hipparchia autonoe* (Esper) (Lepidoptera: Nymphalidae), Natural Monument in South Korea. - Entomological Research, **41** (6): 269-274.
- DENNIS, R.L.H. & T.G. SHREEVE (1989): Butterfly wing morphology variation in the British Isles: the influence of climate behavioural posture and the hostplant-habitat. - Biological Journal of the Linnean Society **38**: 323-348.
- HAMMER, Ø.; D. A. T. HARPER & P. D. RYAN (2001): PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica* **4** (1): 1-9.
- JIA, D. R.; R. J. ABBOTT, T. L. LIU, K. S. MAO, I. V. BARTISH & J. Q. LIU (2012): Out of the Qinghai-Tibet Plateau: evidence for the origin and dispersal of Eurasian temperate plants from a phylogeographic study of *Hippophaë rhamnoides* (Elaeagnaceae). - New Phytologist **194** (4): 1123-1133.
- KUDRNA, O. (1977): A revision of the genus *Hipparchia* Fabricius. - Farington, Oxon: Classey. 204 p.
- LÓPEZ-PUJOL, J.; F. M. ZHANG, H. Q. SUN, T. S. YING, & S. GE (2011): Centres of plant endemism in China: places for survival or for speciation? *Journal of Biogeography* **38** (7): 1267-1280.
- SBORDONI, V.; D. CESARONI, J. COUTSIS & G. C. BOZANO (2018): Guide to the butterfly of the Palearctic region. Satyrinae part 5. - Milano: Omnes Artes. xxx p.
- WANG, J.; R. J. ABBOTT, Y. L. PENG, F. K. DU, & J. Q. LIU (2011). Species delimitation and biogeography of two fir species (*Abies*) in central China: cytoplasmic DNA variation. - *Heredity* **107** (4): 362.
- XU, T. T.; R. J. ABBOTT, R. I. MILNE, K. MAO, F. K. DU, G. L. WU, Z. X. CIREN, G. MIEHE & J. Q. LIU (2010): Phylogeography and allopatric divergence of cypress species (*Cupressus* L.) in the Qinghai-Tibetan Plateau and adjacent regions. - *BMC Evolutionary Biology* **10** (1): 194.
- ZHANG, M. L.; C. H. UHINK & J. W. KADEREIT (2007): Phylogeny and biogeography of *Evpimedium/Vancouveria* (Berberidaceae): Western North American - East Asian disjunctions, the origin of European mountain plant taxa, and East Asian species diversity. - *Systematic Botany* **32** (1): 81-92.
- ZHANG, M. L.; Y. KANG, L. H. ZHOU & D. PODLECH (2009): Phylogenetic origin of *Phyllolobium* with a further implication for diversification of *Astragalus* in China. - *Journal of Integrative Plant Biology* **51** (9): 889-899.

Authors' addresses:

Prof. Valerio Sbordonni and Prof. Donatella Cesaroni
Department of Biology
University of Roma "Tor Vergata"
00133 Roma, Italy

Ing. Gian Cristoforo Bozano
Viale Romagna, 76
20133 Milano, Italy

Table I. Sample localities of specimens used for male genitalia morphometry

population code	measured specimens	subspecies	localities and date of collection
BUR	5	<i>arcellae</i>	China - Qinghai - Burhan Budai (Bu'erhan Buda Shan), 3400-3700m, 7.VIII.90
CHA	2	<i>arcellae</i>	China - Qinghai - North of Chaka Lake (Chakayan Lake), 3500-3700m, 10.VIII.90
GHA	3	<i>celaeno</i>	China - Gansu - Xihai (270 km from Lanzhou), 3000-3500m, 15-30.VIII.90
TEV1	4	<i>autonoe</i>	Mongolia, Terelj Natl. Park, 21.VII.88
BLA	2	<i>autonoe</i>	Russia - Blagoveščensk (Oblast of Amur), 21.VII.88
KRA	1	<i>autonoe</i>	Russia - Central Siberia, Krasnojarsk, 11.VII.68
ALT	2	<i>autonoe</i>	Russia - Altai Mts., Kurai village, 1600m, 7.V.67 and 16.VII.68
LANB	6	<i>extrema</i>	China - Gansu - Lanzhou, 1900m, 13.VII.90