Melitaea telona complex of species (Lepidoptera: Nymphalidae: Nymphalinae: Melitaeini) in the Levant and description of a new species

Dubi Benyamini

Abstract. The representatives of the *Melitaea telona* complex of species (Nymphalidae) in the Levant region are reviewed, certain genitalia traits are analyzed and discussed. The lectotype of *Melitaea phoebe dorae* Graves, 1925, is designated, resulting in *M. phoebe telona* Fruhstorfer, 1908 as a senior species-group name. In our analysis three species are involved: (1) *Melitaea klili* Benyamini, 2021 multi-brooded species, the "ancestor" of the group (with genitalia type A); (2) *Melitaea telona* Fruhstorfer, 1908 single-brooded east Mediterranean species (with genitalia types A and B), and (3) *Melitaea tzinensis* **n. sp.**, which originates in the southern and eastern deserts and desiccated biotopes in the Levant (with genitalia type B). *Melitaea phoebe telona* Fruhstorfer, 1908 is synonymized with *Melitaea phoebe dorae* Graves 1925, **n. syn.** I present the results regarding the male genitalia trait analysis and remark on the evolutionary history of these Levant *M. telona* spp. reflecting the climate change in the east Mediterranean region since the last glacial period.

Samenvatting. De vertegenwoordigers van het *Melitaea telona*-soortencomplex (Nymphalidae) in de Levant worden besproken en bepaalde kenmerken van de genitaliën worden geanalyseerd en besproken. Het lectotype van *Melitaea phoebe dorae* Graves, 1925, wordt aangewezen, met *M. phoebe telona* Fruhstorfer, 1908 als senior soort-groep naam. In onze analyse gaat het om drie soorten: (1) *Melitaea klili* Benyamini, 2021, een soort met meerdere generaties per jaar, de "stamvader" van de groep (met genitaliën type A); (2) *Melitaea telona* Fruhstorfer, 1908, een oost-mediterane soort met slechts één generatie (met genitaliën type A en B) en (3) *Melitaea tzinensis* **n. sp.** die afkomstig is uit de zuidelijke en oostelijke woestijnen en verdroogde biotopen in de Levant (met genitaliën type B). *Melitaea phoebe telona* Fruhstorfer, 1908 is gesynonymiseerd met *Melitaea phoebe dorae* Graves, 1925, **n. syn**. Ik presenteer de resultaten betreffende de analyse van de kenmerken van de mannelijke genitaliën en maak opmerkingen over de evolutionaire geschiedenis van deze *M. telona* spp. in de Levant, die de klimaatverandering in het oostelijke Middellandse-Zeegebied sinds de laatste ijstijd weerspiegelt.

Résumé. Les représentants du complexe d'espèces *Melitaea telona* (Nymphalidae) dans la région du Levant sont passés en revue, certains caractères génitaux sont analysés et discutés. Le lectotype de *Melitaea phoebe dorae* Graves, 1925, est désigné, avec comme résultante *M. phoebe telona* Fruhstorfer, 1908 comme nom supérieur. Dans notre analyse, trois espèces sont impliquées: (1) *Melitaea klili* Benyamini, 2021 espèce multi-brodée, "l'ancêtre" du groupe (avec des genitalia de type A); (2*) Melitaea telona* Fruhstorfer, 1908 espèce méditerranéenne orientale à un seul code (avec des genitalia de types A et B) et (3) *Melitaea tzinensis* **n. sp.** qui est originaire des déserts du sud et de l'est et des biotopes desséchés du Levant (avec des genitalia de type B). *Melitaea phoebe telona* Fruhstorfer, 1908 est synonymisé avec *Melitaea phoebe dorae* Graves, 1925, **n. syn**. Je présente les résultats concernant l'analyse des caractéristiques des genitalia mâles et donne des remarques sur l'histoire évolutive de ces *M. telona* spp. du Levant, reflétant le changement climatique dans la région de la Méditerranée orientale depuis la dernière période glaciaire.

Key words: *Melitaea telona* — *Melitaea klili* — Middle East — New species — Climate change — Lectotype — Nymphalidae.

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DOI: 10.6084/m9.figshare.22722907

Introduction

The Levant (eastern Mediterranean) life zone is the only place on the globe where two main zoogeographical regions, the Palaearctic and Afrotropical with their southern and northern ecotones (respectively), meet in a unique crossroads, where three additional sub-regions i.e. Irano Turanian eastern steppes, Saharo-Sindian eremic zone and Sudanian Rift-Valley tropical penetrating zone, support the evolutionary history of the *Melitaea telona* species complex consisting of three species *Meliteae klili* Benyamini, 2021, *M. telona* Fruhstorfer, 1908, and *M. tzinensis* **sp. n**. The biogeography of the complex in the Levant following the dramatic Paleoclimate changes since the last glacial post-Pleistocene (Torfstein & Enzel 2017; Goldreich 1998; Frumkin & Comay 2021; Ludwig & Hochman 2021) is explained in this paper. In his cornerstone publication on the "Rhopalocera and Grypocera of Palestine and Transjordania", Philip Perceval Graves (1856–1953), in the pages of the journal *Transactions of the Royal Entomological Society of London*, summarized the butterfly knowledge gathered in Palestine from the late 19th century, before, during and post WWI, mostly by British officers on tour of duty (Graves 1925). Among his 79 listed taxa there were four "nova" sspp. and four additional species that he refrained from naming. In this paper, I revise the nominal taxon which P.P. Graves described as *Melitaea phoebe dorae* and present the knowledge of our group on the *Melitaea telona* species complex (see Benyamini 2021). Furthermore, I describe below a new species. No less than 83 male genitalia from 18 localities from south Jordan's desert to the Lebanese mountains 520 km away, from specimens spanning 115 years from 1907 (Jerusalem, type locality of *M. telona*) until spring 2022 (Nahal Shezor, type locality of *M. klili*), were dissected and their valval distal process (VDP) documented and measured (Fig. 1a). The larval hostplants of all the taxa involved are also given.

Abbreviations:

BMNH = British Museum of Natural History, London (now Natural History Museum, London (NHMUK)); DB = Dubi Benyamini; L = larva; LHP = larval host plant; TL = type locality; VDP = valval distal process; WL = wing length (measured from forewing base to apex).

Fig. 1a. VDP types A and B of 83 *Melitaea telona* complex specimens in 18 biotopes of Levant.

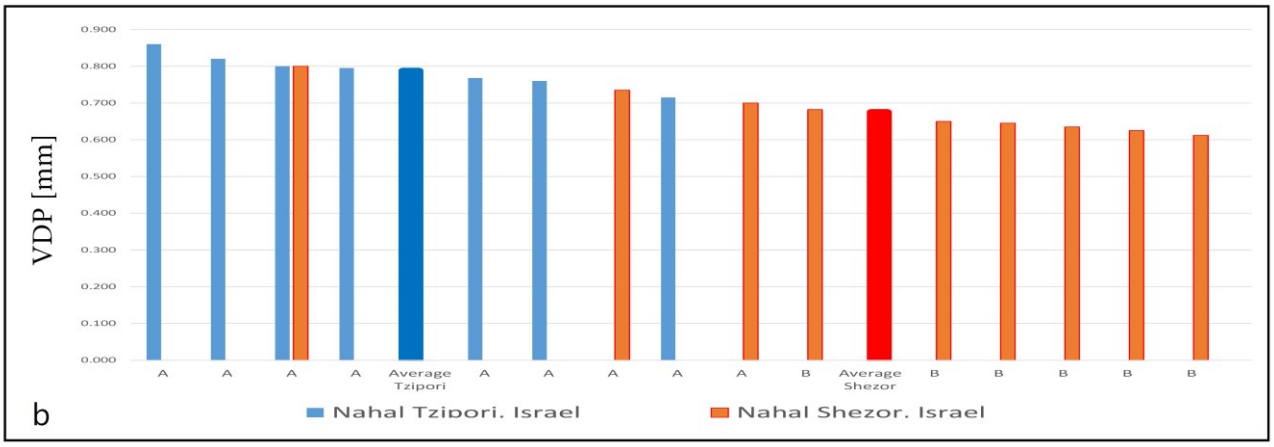


Fig. 1b. VDP length (in mm) and type A or B of *Melitaea klili* in its two western Galilee localities: Nabal Tzipori – blue type A (average 0.788 mm) and Nahal Shezor – orange types A and B (average 0.676 mm).

Fig. 1c. VDP length (in mm of 22 *Melitaea telona* specimens collected in Jerusalem between 1907 and 1922 with average decline values.

The problematic description of "*Melitaea phoebe* subsp. *dorae*"

A bright form with reduced black markings, "Rather small race, larger than Beirut *telona*" of "*Melitaea phoebe telona*" that were collected in Petra, Edom, central–southern Jordan, attracted P. P. Graves' attention and he dedicated considerable space to examining 13 males and three females of this "race" and compared it with 15 *M. phoebe telona* Fruhstorfer, 1908 males from Transjordan (northern areas), Mar Saba (Judean Desert in Israel), Judaea (Israel) and Beirut to six males of *M. phoebe ogygia* Fruhstorfer, 1908 from Athens and one male *Melitaea phoebe* ([Denis & Schiffermüller], 1775) "from the Engadine (Switzerland) in the British Museum for comparison". To do this tiresome comparison he divided the upper surface of the forewing into three sections, and the hindwing into five sections; each section received an index figure of its "nigrescence" between 1 (no black markings) and 10 ("entirely suffused black"). The results of this interesting comparison are presented in one of Graves' paper (1925: 105). The results show clearly the "nigrescence" increase from the bright desert "race" *dorae* (average index number 21.96) through *telona* (29.89), to the darker Greek *M. phoebe ogygia* (36.30) and the darkest: Swiss *M. phoebe* (50). While the results indicate brighter specimens in southern localities, which is normal because of its higher solar radiation, there are some annoying facts in Graves' meticulous treatment:

- It seems that the Petra specimens that were collected by H. St. J. Philby in March 1922 and March 1923 are a local selected group not representing the whole Edom population where normal *M. telona* species is quite widespread i.e. records of collected *M. telona* specimens in Dana reserve (Edom) only 45 km northwards (leg. DB, coll. DB).
- Specimens without markings on the hindwings appear normally in all the Levant's *M. telona* species complex populations in changing percentages. This includes bred specimens of *M. klili* from the Tzipori and Shezor biotopes where *M. phoebe dorae* or partial *M. phobae dorae* specimens with reduced "nigrescence" appear together with normal forms. These mixed forms may be the offspring from the same egg batch of one female (following DB breeding notes).
- P.P. Graves refrained from designating the holotype or "type" in his original description and the yellow round labels marking the Petra material as "co-types" were added later by the staff of the NHMUK (ex BMNH) (Fig. 4).

Designation of the lectotype for *Melitaea phoebe dorae* Graves, 1925

The specimen selected and designated here as lectotype by DB was listed by P.P. Graves amongst the studied material. It is a male specimen, set dorsally in perfect condition (no damage) with forewing costa length 19.2 mm, with two original labels: (1) "Trans Jordan, Petra, 26. iii.1929" and (2) "H. St. J. Philby" (both rectangular, white paper with black printed letters). There are two subsequent labels: "B. M. TYPE No. 8284" and "Photograph No. NHMUK 014172682". We have added a white label with the printed letters: "*Melitaea phoebe dorae* Graves, 1925; designated by Dubi Benyamini, 2023", and a red label with the printed letters: LECTOTYPE (Fig. 4). The lectotype specimen now objectively represents the nominal taxon *Melitaea phoebe dorae* Graves, 1925 and fixes its identity. The lectotype is deposited in the collection of NHM, London.

On the basis of wing pattern and geographical location of the type locality, I consider: ***Melitaea phoebe telona*** Fruhstorfer, 1908

= *Melitaea phoebe dorae* Graves, 1925, **new synonym.** For details see the following considerations.

The *Melitaea telona* species group and their historic perspective

Melitaea klili Benyamini, 2021

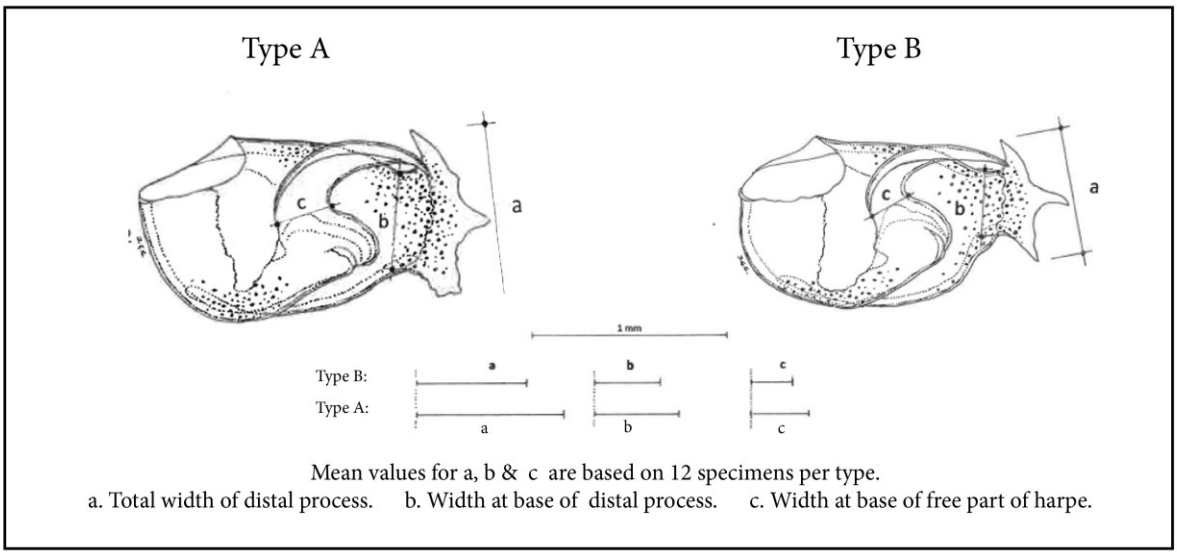
Since about twenty thousand years ago, from the end of the last glacial period, when the climate was wetter and *Centaurea* LHPs flourished during longer springs, we had only *Melitaea klili* the "ancestor" – similar to the population of today's Tzipori rivulet refuge (Fig. 5) where the *Melitaea "telona"* are multi-brooded and the VDP is mostly* the large type A (Fig. 1b). This taxon's survivability during so many years is due to its unique genetics and epigenetics usually unknown in other papilionoids – their larvae at L3, L4 and L5 start long-term annual diapause whenever the food is in short supply; whilst in most other species the starving larvae die or, seldomly, pupate to produce dwarf adults. Their relict local populations testify that they could survive sudden hot and dry weather conditions during former inter-glaciation periods. The LHPs of *M. klili* in Shezor and Tzipori biotopes are large perennial pink-flowered *Centaurea iberica* var. *sepphoris* (Benyamini 2021) (Fig. 5).

Additional *M. klili* populations possibly exist further north of Israel along the Levant coast in wet biotopes:

(a) In Lebanon around Beirut where the existence of three annual broods was reported: "On the coast there are two further broods, one in June/July, another in August/September, but both are much less numerous than the first" (Larsen 1974: 123), as in the Israeli west Galilee populations.

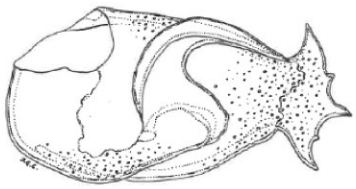
(b) The Syrian Mediterranean coast near Latakia may have similar unexplored wet biotopes with *M. klili* multi-generation populations (Benyamini 2021: 190).

* The wider upstream Nahal Tzipori at Ka'abiyye-Tabbash-Hajajre narrows downstream at the "Tahanat HaNezirim" (the Monk's Mill), where on both sides of the valley the adjacent mountain slopes are the home of single-brooded *M. telona*, hence the reason for having a mix of both species in *M. klili* type-locality and biotopes in western Galilee.

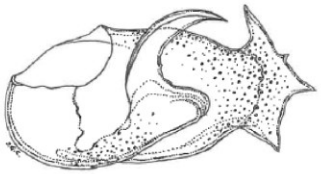


Mean values for a, b & c are based on 12 specimens per type.
a. Total width of distal process. b. Width at base of distal process. c. Width at base of free part of harpe.

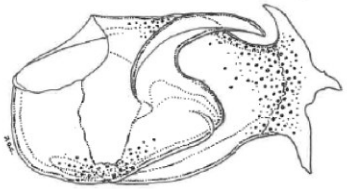
VDP- Type A



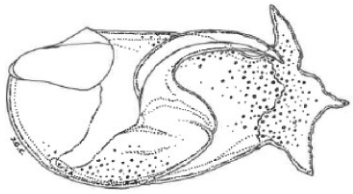
6270- LECTOTYPE M. *telona*
Jerusalem. Palestine (Israel) , VDP = 0.740 mm



6293- HOLOTYPE M. *klili*
Nahal Shezor, W Galilee, Israel , VDP = 0.735 mm

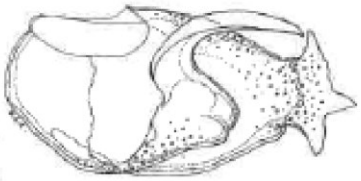


6103- M. *klili* - Nahal Tzipori,
W Galilee, Israel , VDP = 0.860 mm

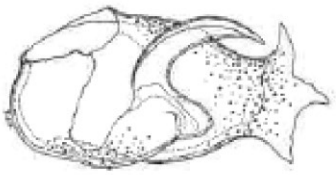


6292- M. *klili* -
Herzelia, Coastal Plain, Israel , VDP = 0.887 mm

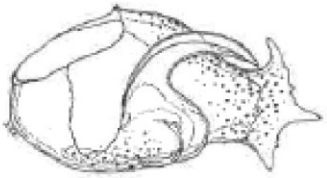
VDP- Type B



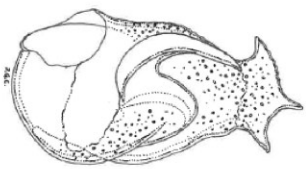
6054- HOLOTYPE M. *tzinensis*
Wadi Nafha, Negev, Israel, VDP = 0.630 mm



6092- PARATYPE 01 M. *tzinensis*
Wadi Dana, 545 m. Edom, Jordan, VDP = 0.690 mm



6091- PARATYPE 02 M. *tzinensis*
Gebel Rum 1100 m, S Jordan, VDP = 0.650 mm



6244- PARATYPE 03 M. *tzinensis*
Mt Hermon, 1600 m, Israel, VDP = 0.575 mm

Fig. 2. Genitalia drawings of *Melitaea telona* Lectotype, *M. klili* Holotype, all *M. tzinensis* types + largest VDP type A and smallest VDP type B are drawn for comparison by John Coutsis. © John Coutsis.

Melitaea telona Fruhstorfer, 1908

When the long-term desiccation process (which is increasing at present) started and the LHP became in shorter supply, i.e. because of shorter springs, shorter flowering period and less available food, the number of annual broods decreased to one and *Melitaea telona* appeared in moderate VDP sizes; mostly type A lower values presented by the lectotype, paralectotypes and most specimens in the Levant and possibly southern Europe. The known *telona*'s LHPs in the Levant include Asteraceae: *Carduus argentatus* L., *Carthamus tenuis* (Boiss. & C.I.Blanche) Bornm., *Centaurea aegyptiaca* L., *C. crocodylium* L., *C. cyanoides* Berger, *C. eryngioides* Lam., *C. hyalolepis* Boiss., *C. iberica* Trevir. ex Spreng., *Crupina crupinastrum* (Moris) Vis., *Cynara syriaca* Boiss., *Notobasis syriaca* (L.) Cass., *Silybum marianum*, (L.) Gaertn.; Dipsaceae: *Scabiosa* sp.; Plantaginaceae: *Plantago* sp. (Benyamini 2021: 188). Additional *telona* broods in natural conditions are rare in its southern distribution limit.

In Israel: we know of only one specimen collected in Herzelia on 2.vi.1954 (Steinhardt Museum collection) and Graves (1925) "have seen no 2 Gen. specimens from Palestine". No voucher specimen exists.

In Jordan: P. P. Graves did not find a second generation of the southern ssp. *dorae* ("the second generation is unknown") except "a dark rather worn male specimen taken at Wadi Sir on 14.viii.1923.". The voucher of this record has not been located. Larsen and Nakamura (1983) did not report a second brood except P.P. Graves' record.

In Lebanon: T. Larsen (1974: 123) reported "less common" August specimens in the mountains in "damp places". Peter Russell who bred genuine *Melitaea telona* from the Galilee (Golani junction) found that in his laboratory with fresh juicy *Centaurea* plants, Israelian *Melitaea telona* population may produce a second brood unknown in its natural biotope where it uses a different LHP (pers. comm. to DB). These rare second-brooded *M. telona* specimens provide additional proof that *M. telona* and *M. klili* originated from the common ancestor.

Legend

No.	Location	Type
1	Laqlouq, Lebanon,	B
2	Beirut, Lebanon	A
3	Mt. Hermon, Israel	B
4	Nahal Aviv, Israel	A
5	Nahal Shezor, Israel	A+B
6	Haifa, Israel	B
7	Nahal Tzipori, Israel	A+B
8	Herzeliya, Israel	A
9	Nahal Shilo, Israel	A+B
10	Ma'ale Efraim. Israel	A
11	Ein Sinya, Israel	A
12	Jerusalem, Israel	A+B
13	Wadi Zarga, Jordan	B
14	Arad, Israel	A
15	Ein Avdat, Israel	A
16	Wadi Nafha, Israel	B
17	Wadi Dana 545m, Jordan	B
18	Gebel Rum 1100m, Jordan	B

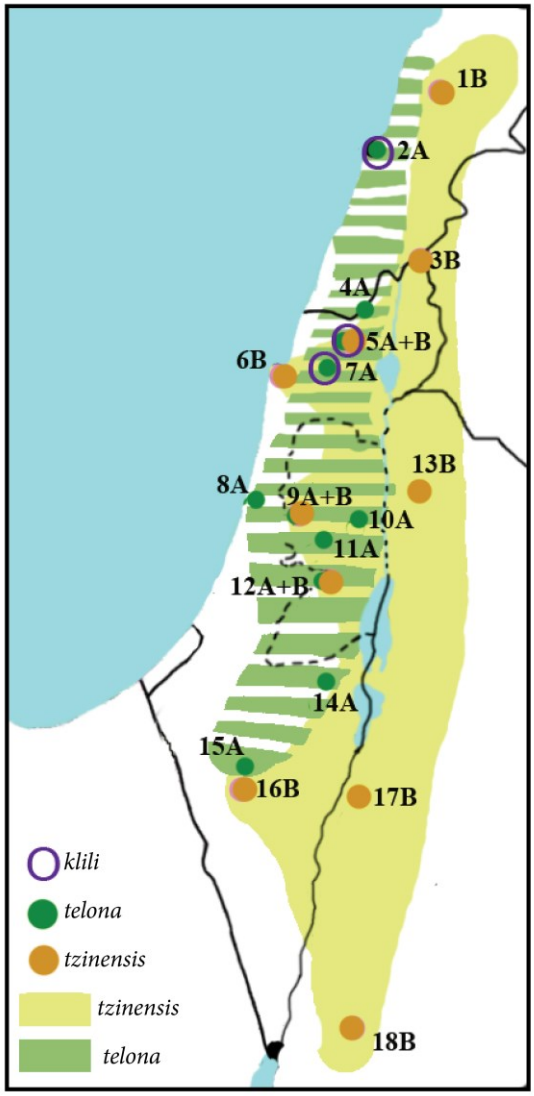


Fig. 3. Distribution of *Melitaea klili*, *M. telona* and *M. tzinensis*. VDP types A & B in southern Levant.

Melitaea tzinensis Benyamini, new species

The intensification of Levant's desertification shortened springs; shorter flowering period and earlier dehydration of the *Centaurea*'s main LHP stressed the single-brooded *M*. *telona* furthermore to produce smaller, *M*. *dorae*-size adults and to find additional alternative LHPs — e.g. at the Central Negev Mountains, the TL of the new species, these are *Centaurea eryngioides* Lam., *C*. *hyalolepis* Boiss., *C*. *pallescens* Delile on top of *C*. *iberica* Trevir. ex Spreng. In the Northern Negev at Nir Moshe grove they also lay eggs on *Crupina crupinastrum* (Moris) Vis. (Asteraceae). Further southwards in south Jordan's southern limit of *Melitaea telona* species group on top of Gebel Rum (29°34'46''N : 35°22'32''E, 1170 m), only 30 km short of Saudi-Arabian border, its LHP is the beautiful large-flowered *Centaurea eryngioides* Lam. that survives in rock cracks (Fig. 5). In these biotopes, *M. tzinensis* **n. sp**. with shorter VDP type B appeared. In fact, all the southern and eastern *M*. "*telona*s" are actually *M*. *tzinensis* and in the future when *M*. *klili* will disappear first, the *M*. *telona* will follow, and the *M*. *tzinensis* will expand northward with the deserts to become the dominant species.

Description of *Melitaea tzinensis* Benyamini, new species

LSID: urn:lsid:zoobank.org:pub:07391E98-B6EA-40BC-9428-2F24ACA28D44

Type material

Holotype, male, wingspan 20.30 mm. Labelled as: "W. Nafha (Handwritten) [/] ISRAEL (Printed) [/] 2.4.1976 (Handwritten) [/] D. Benyamini (Printed)".

Paratypes, three males (nos 01–03): 01 labelled as: "W. Dana (Handwritten) [/] 27.3.99 , 545 m (Handwritten) [/] JORDAN (Handwritten)". 02 labelled as: "W. Gebel Rum 1100m (Printed) [/] 8.4.2000 S. JORDAN (Printed) [/] Leg. Dubi Benyamini (Printed)". 03 labelled as: "HERMON 1630 m (Handwritten in Hebrew) [/] 21/7/22 (Handwritten) [/] Leg D.B (Handwritten)". All the type material will be deposited in the Steinhardt Museum of Natural History, Ramat Aviv, Tel Aviv, Israel.

Description

WL (n=4; holotype + paratype nos 1–3) 17.4–20.3 mm; average: 18.85 mm. Wing upperside ground colour near Pumpkin (see Maerz & Rea 1950: G10 PL 10), submarginal band colour between Marathon (see Maerz & Rea 1950: J12 PL11) and Punjab (see Maerz & Rea 1950: J12 PL 12) with pattern typical for the genus (Fig. 4).

Genitalia with VDP small type B with range of 0.575–0.690 mm (Figs 1, 2).

Diagnosis

It is a small single-brooded species of dry biotopes in Jordan, Negev Israel, west Syria on the eastern slopes of the Anti-Lebanon, and strays into dry biotopes in coastal south Levant (Fig. 3). Amongst the *M*. *telona* complex this new species has the smallest male genitalia valva with the VDP mean value 0.643 mm (n=16) of type B, compared with *M*. *telona* mean value 0.758 mm (n=43) of type A and *M. klili* mean value 0.788 mm of type A (Nahal Tzipori), and with mean value 0.676 mm of mixed types A and B (Nahal Shezor) (Figs 1a, b).

Etymology

The name comes from Nahal Tzin (Zin), *tzinensis* type locality — a large east-west Negev wadi, where the holotype was collected by the author.

Discussion

The present-day Levant distributional map (Fig. 3) clearly highlights this ecological process with the dominant *M*. *telona* in the middle (green strips and spots), disappearing *M*. *klili* enclaves in western Galilee and Beirut (blue circles) and the southern new species *M*. *tzinensis* that will eventually expand northwards from its origin in the southern and eastern deserts of south Jordan and central Negev in south Israel to become the dominant single-brooded species with small VDP and the habitus with orange spots over yellow background.

General analysis of VDP

Two groups are defined on the basis of genitalia traits: (1) type A = the large VDP with 0.700 to 0.887 mm long which correlates to *Melitaea klili* and *Melitaea telona* and (2) type B = the short VDP with 0.575 to 0.693 mm long which correlates to *Melitaea tzinensis* **n. sp.** (Figs. 1a, 2).

VDP comparison of *M*. *klili* from localities in western Galilee presents the proof that the ecological process is evident. We compared the Nahal Tzipori wet biotope with a permanent flowing rivulet and its nearly dominant *M. klili* population with up to three annual broods, and type A VDP (average 0.788 mm, n=18) with the Nahal Shezor desiccated biotope that is actually a typical wadi (dry valley bed) with only remnants of the wet biotope it used to be. Here we find the widest VDPs range from the archaic type A VDP it used to be to the newcomer "invading" type B = my new species that will evidently become the dominant and only species present of the *M. telona* complex (average 0.676 mm, n=21) (Fig. 1b). This newcomer will have to cope with the expanding deserts, in the Anthropocene era, and will possibly have to change its LHP or add desert LHPs in order to survive. Like Pieridae spp. with long term pupal diapause (Benyamini 2008), probably future generations of lepidopterists may discover that similar long-term diapause will/might also appear in the *Melitaea* spp.

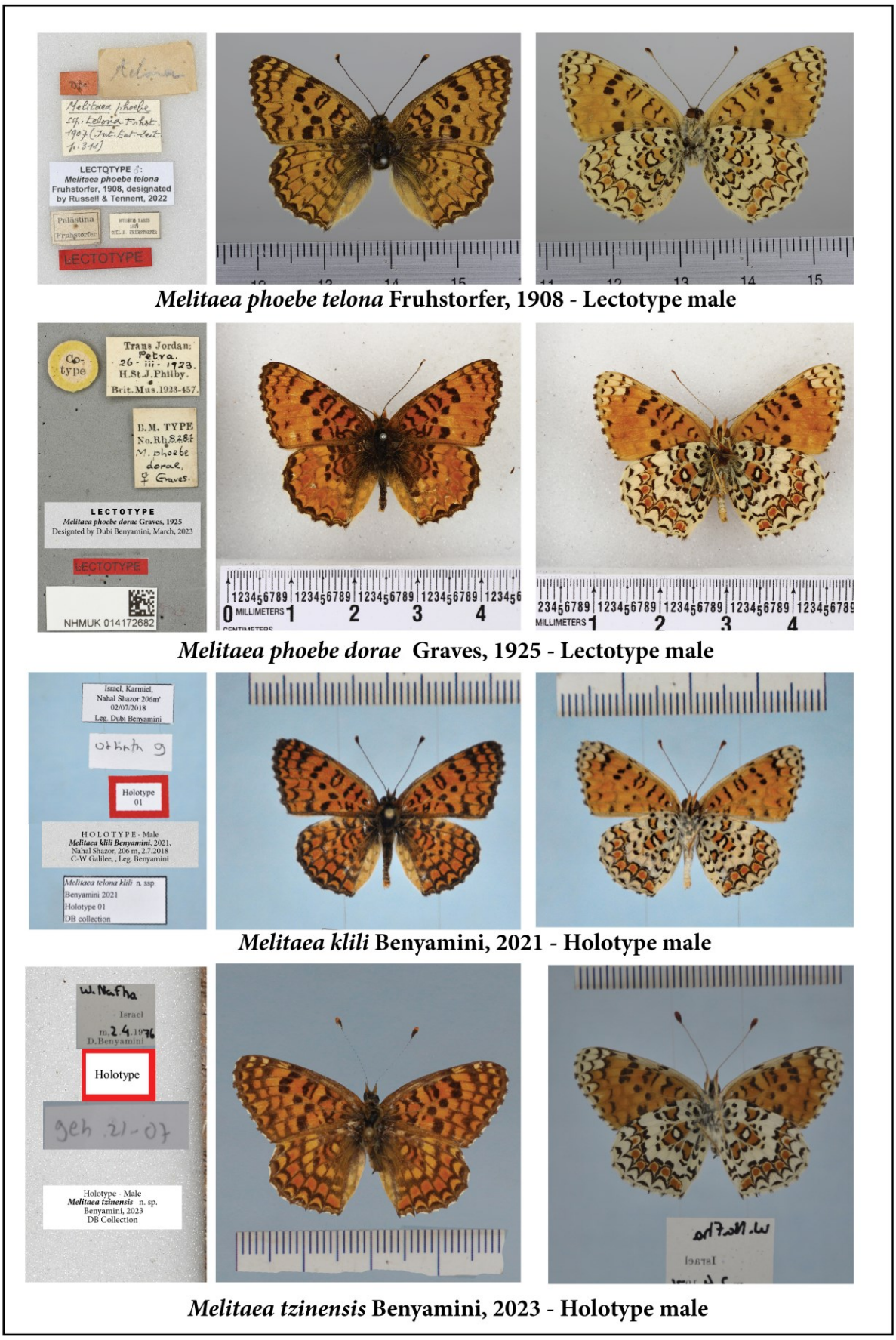


Fig. 4. Lectotypes of *Melitaea telona* and *M. dorae*. Holotypes of *M. klili* and *M. tzinensis* **n. sp.**

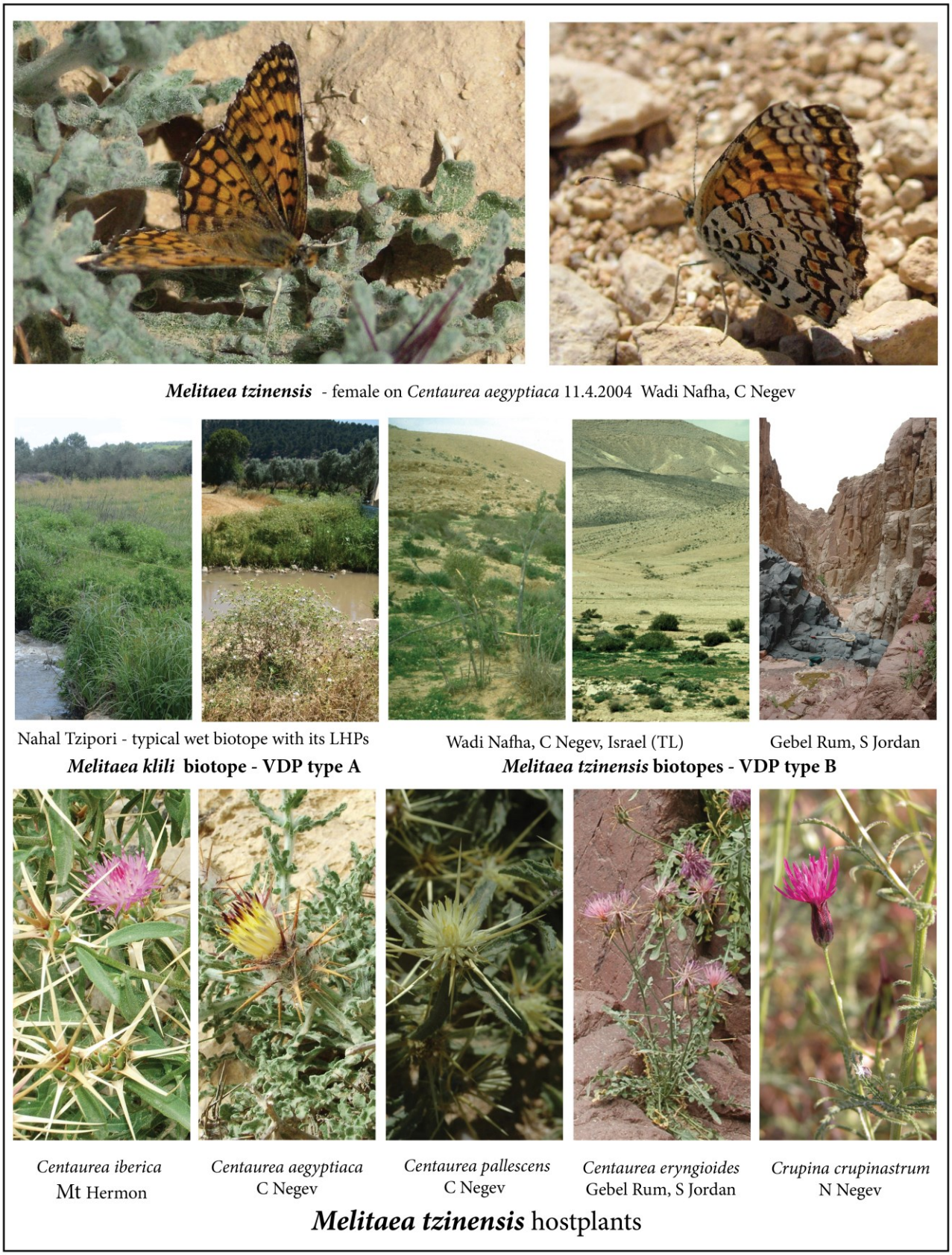


Fig. 5. *Melitaea tzinensis* **n. sp**. Type locality: Wadi Nafha; female in TL and on LHP.
M. klili wet biotope at Nahal (Rivulet) Tzipori with *Centaurea iberica* as LHP, Galilee, Israel.

Comparison of VDP in material collected in Jerusalem 1907–2022

We compared the material collected in Jerusalem from 1907 until 2022 and based our comparisons on type specimens deposited in DB & Steinhardt N.H. collections. We tried to check the long-term change of VDPs of 22 collected males collected in Jerusalem and neighbouring plateaux localities between 1907 (lectotype and two paralectotypes) and 2022 (Nahal Shilo). We received a very moderate average VDP decline from 0.752 mm to 0.721 mm over the 105 years. This slight but clear decline expresses the trend of desertification process in the east Mediterranean and the ongoing process of change of populations from *M. klili* (wide type A) through *M. telona* (types A and B) to *M. tzinensis* (small type B) (Fig. 1c).

DNA sequencing results

DNA sequencing of *M. telona, M. klili, M. tzinensis* **n. sp.** done for us in Barcelona (CSIC-UPF labs, Vila pers. comm. to DB) showed only tiny negligible changes between the species of *M. telona* complex. It seems that this molecular clock is not the sensitive tool that we need for such a quick and accelerating speciation process that we face in our Anthropocene period, and thus it cannot sense this change. In fact, the evolutional epigenetic cell memory left us a few clues to understanding the dramatic species-changeover from archaic *M. klili* through present day *M. telona* to the final and dominant survivor *M. tzinensis* **n. sp.** in the future.

Acknowledgements

John G. Coutsis of Athens, the leading and most experienced Greek lepidopterist, is cordially thanked. His drawings of male genitalia of all the *M. telona* species complex enabled the author to make the breakthrough of understanding the evolutionary history of this complex — thank you, John, for your precise and perfect drawings.

DB's devoted assistant Mr Ofir Tomer, the new butterfly collection manager at the Steinhardt Natural History Museum, Tel Aviv is DB's helper in the field. In this article he prepared the VDP figures based on the drawings of John Coutsis. Dr Zsolt Bálint, the leading curator of butterflies in the Hungarian Natural History Museum read the draft of this article; his remarks were accepted willingly. Dr Orr Comay (HaMaarag, Israel) assisted with Levant's Paleoclimate, sent relevant publications to DB and commented on the draft of this article. Peter Russell bred (in the UK) L3 larvae from *M. klili* biotopes in the Western Galilee, Israel, supplied by DB; this mutual experiment is still unfinished. Roger Vila and Cecilia Corbella Felip (CSIC — UPF) Barcelona, Spain carried out the DNA sequencing of our *M. telona* complex specimens. Thanks to the anonymous English editor for his fine editing. The gifted Leah Benyamini prepared the colour plates and made the final touch-up of the manuscript.

To all these people, the author extends his sincere thanks.

References

Benyamini D. 2008. Is *Euchloe falloui* Allard, 1867 (Pieridae) the butterfly with the longest diapause? — *Nota Lepidopterologica* **31**(2): 293–295. https://www.biodiversitylibrary.org/page/9648659

Benyamini D. 2021. *Butterflies of the Levant Vol III Nymphalidae*. — 4 D MicroRobotics Ltd. Israel, 240 pp.

Frumkin A. & Comay O. 2021. The last glacial cycle of the southern Levant: Paleoenvironment and chronology of modern humans. — *Journal of Human Evolution* **160**: 1–8.

Goldreich Y. 1998. *The Climate of Israel – Observations, Research and Applications*. — Khidekel publishing house, Tel-Aviv. 292 pp.

Graves P. P. 1925. The Rhopalocera and Grypocera of Palestine and Transjordania. — *Transactions of the Royal Entomological Society of London* **73**(1–2): 17–125.

Larsen T. B. 1974. *Butterflies of Lebanon*. — National Council for Scientific Research, Beirut, 256 pp.

Ludwig P. & Hochman A. 2021. Last glacial maximum hydro-climate and cyclone characteristics in the Levant: a regional modelling perspective. — *Environmental Research Letters* **17**: 014053: (1–15). https://doi.org/10.1088/1748-9326/ac46ea

Maerz A. & Rea P. M. 1950. *A Dictionary of Color*. — McGraw-Hill Book Company, Inc., 208 pp.

Torfstein A. & Enzel Y. 2017. Dead Sea Lake level change and Levant Palaeoclimate. — *In*: Enzel Y. & Bar-Yosef O. *Quaternary of the Levant : Environments, Climate Change, and Humans*. — Cambridge University Press, pp. 115–125.