Observations suggesting extended pupal diapause in *Pontia chloridice* (Hübner, [1813]) (Lepidoptera: Pieridae, Pierinae) in Cyprus and Greece

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Abstract. The autumn disappearance of *Pontia chloridice* from known sites in Cyprus suggests an ability of the species to remain in facultative pupal diapause during periods of unfavourable conditions, as is known with at least one other congeneric species. It is thought that *P. chloridice* is not migratory in the eastern Mediterranean, and that populations in Cyprus and NE Greece do not depend on reinforcement from immigration.

Samenvatting. De verdwijning van *Pontia chloridice* in de herfst van bekende locaties op Cyprus wijst op het vermogen van de soort om in facultatieve popdiapauze te blijven tijdens perioden van ongunstige omstandigheden, zoals bekend is van ten minste één andere congenerische soort. Er wordt aangenomen dat *P. chloridice* niet migreert in het oostelijke Middellandse Zeegebied, terwijl de populaties in Cyprus en Noordoost-Griekenland niet afhankelijk zijn van versterking door immigratie.

Résumé. La disparition automnale de *Pontia chloridice* des sites connus à Chypre indique une capacité de l'espèce à rester en diapause nymphale facultative pendant des conditions défavorables périodiques, comme cela est connu avec au moins une autre espèce congénérique. Il est considéré que *P. chloridice* n'est pas migratrice en Méditerranée orientale, les populations de Chypre et du nord-est de la Grèce ne comptant pas sur le renforcement par l'immigration.

Key words: Balkans — Cleomaceae — Eastern Mediterranean — Facultative pupal diapause — Migration — Turkey.

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Introduction

Pontia chloridice (Hübner, [1813]), the Small Bath White, is classified as being of 'Least Concern' in the European and Mediterranean IUCN Red Lists of butterflies (Van Swaay *et al*. 2010; Numa *et al*. 2016). However, it is an infrequently encountered species in Cyprus, where John & Makris (*in prep.*) stated, 'Unsuitable geology probably accounts for the absence of the hostplants from the northern ranges of limestones, chalks and marls, restricting *P. chloridice* to the igneous rocks of the Tróodos range and foothills above 400 m. Unlike the polyphagous *Pontia daplidice* (Linnaeus, 1758), larval hostplants of *P. chloridice* in Cyprus form just two members of the Cleomaceae, *Cleome ornithopodioides* L. and *Cleome iberica* DC. (John *et al*. 2008; John, Makris & Christofides 2013; John & Skule 2016: 294), both similarly confined to the Tróodos range (Meikle 1977: 173–176). In Greece, *P. chloridice* is highly localized and found only in north-eastern areas of the country, close to the borders with Bulgaria and Turkey (Anastassíu, Coutsis & Ghavalas 2016).

Turner (1920), citing unpublished notes made in 1916 by Sir John Bucknill (Judge Advocate of Cyprus from 1907 to 1912) reported, 'this species [*P. chloridice*] was taken in Cyprus by Mr. Marsden', but without stating the year of capture. Turner further quoted from correspondence with G. F. Wilson of the Chief Secretary's Office in Cyprus at the time (and through whom access to Bucknill's notes had been gained), in which Wilson was reported to have taken *P. chloridice* in 1918, 'near Platres at which locality it was once before recorded *many years ago*' (current authors' italics). Thus, Rebel's (1939) statement (with reference to Turner 1920) that 'The species was first caught … in 1916 …' appears to be inaccurate, but we have no clear indication in which year the first specimen of *P. chloridice* was taken in Cyprus. The taxon was suspected by Parker (1983) to breed on the island, and was confirmed as doing so in 1997 (Makris 2003: 110).

Presence of *Pontia chloridice* in the eastern Mediterranean

In nearby southern coastal provinces of Mediterranean Turkey, *P. chloridice* was stated to be present in Muğla and Antalya Provinces and in the extreme west of Mersin (formerly İçel) Province, but was unreported from eastern coastal areas by Hesselbarth, van Oorschot & Wagener (1995: 589) and by Atahan *et al*. (2018). The website, AdaMerOs-Butterflies of Turkey (2021), displays 116 photographs of *P. chloridice* from provinces throughout much of Turkey, including 11 taken in Antalya Province to the west of Mersin, but with none from the latter. However, another Turkish website includes two photographs of *P. chloridice* taken in Mersin Province in the summers of 2011 and 2012, one which was photographed at Anamur close to the south coast (Trakel undated); this would place the nearest Cyprus populations ca. 130 km to the south. Prior to 2011, the closest known mainland location to the Cyprus populations of *P. chloridice* appeared to be west of Anamur (150 m) near the junctions of Mersin and Antalya Provinces, where a record dating back to April 1976 was listed by Koçak (1989) and Hesselbarth, van Oorschot & Wagener (1995: 589). Onat Başbay (pers. comm. to first author) reported seeing the species near Çıralı (15 m) and at many different elevations in Antalya Province. *P. chloridice* has a widespread, if disjunct, distribution in Turkey (Koçak & Kemal 2012: 51; Kemal & Koçak 2013; AdaMerOs 2021) including in the south-eastern provinces of Şanlıurfa, Şırnak and Hakkâri. To the south of these lies the border with Syria and from which it might be deduced that the species' presence in the north of that country *is* likely, but

Figs 1–2. Young plants (foreground left and centre) of *Cleome ornithopodioides* growing in a typical Cyprus biotope (450 m), Tróodos foothills, 1 June 2013. © Eddie John.

it remains unknown from Mediterranean Syria (Mudar Salimeh, pers. comm. to first author).

An absence of records from Lebanon (Larsen 1974; Merit & Merit 2004, 2008; Bálint, Yammine & Katona 2016; Zorkot 2016) and other countries of the Levant immediately to the east and south of Cyprus, indicates that Cyprus represents the southernmost extent of the species' range in the Mediterranean basin (see distribution maps in Tshikolovets 2011: 120; Benyamini & John 2020: 78).

On the AdaMerOs-Butterflies of Turkey (2021) website, several photographs of *P. chloridice* taken in July of various years depict a 'summer form' having much reduced green scaling; this is evident, too, on the June specimen shown on the Trakel (undated) website. A similar dry-season form is known with *Pontia glauconome* Klug, 1829, as shown in John *et al*. (2020: Fig. 18).

Pontia chloridice – a migratory species?

In their classification of migratory butterflies, Eitschberger, Reinhardt & Steiniger (1991) listed *P. chloridice* among Group 111 migrants: 'Emigrants = Binnenwanderer', i.e. 'Species which migrate within their area of occurrence and do not return to the original areas from which they came, i.e. they stay in their destined area.' Migration is '… neither yearly nor periodic … is not a prerequisite for the maintenance of populations'. Back (1976) proposed such a classification for *P. chloridice* following the discovery of a single female in the Republic of Macedonia, which he assumed to be a migrant. However, after several field trips revealed breeding populations in localities in the Vardar River valley, this opinion was challenged by Franeta, Kogovšek & Verovnik (2012), who concluded that the species is a permanent resident in Macedonia. Nevertheless, earlier observations of *P. chloridice* in Latvia in the summer of 1932 (Brandt 1985) and in Finland in July and August 1970 (Keynäs & Mikkola 1970; Karvonen & Karvonen 1983), were assumed to have been migrants from Russia, indicating evidence of migratory ability. Other than the observations described, evidence of migration is sparse.

Referring to specimens caught in Cyprus on 18 May and 7 July in the early 1900s, Turner (1920) stated, 'The specimens are the worse for wear, and the suggestion is that they are immigrants from the mainland.' Parker (1993) considered this a possibility, while Manil (1990) had no such reservations and stated the species to be migratory. Yet, the propensity for *P. chloridice* to migrate south, i.e. to the limit of the species' range in the eastern Mediterranean seems highly questionable (even though the distance separating coastal 'populations' of *P. chloridice* in Mersin Province, Turkey from northern Cyprus is a mere 75 km). It is difficult to imagine any possible reason for this species to migrate southwards from Turkey at *any* time, but especially in the earlier part of the year when the well-established activity in the region is for other migrant species to move N or NW at that time (e.g. Stefanescu *et al*. 2016; John, Hawkes & Walliker 2019). Nor have there been any reported observations of migratory activity involving this species in Cyprus, regardless of flight direction. A similar view pertains in Greece, where Nick Ghavalas and Hrístos Anastassíu concur with the view of the second author that *P. chloridice* inhabits only the north-eastern area of the country, where it is to be met with in good numbers in very localized colonies; it has never been seen anywhere else in Greece despite many years of intensive study.

However, an unanswered question remains – that of the disappearance of *P. chloridice* in the autumn of some years from known sites in Cyprus.

Cyprus, October 2017 – results and discussion

Prior to a 2017 autumn visit by the first author, Cyprus had experienced two unusually dry winters in 2015–2016 and 2016–2017, followed by typically hot Mediterranean summers. Searches for the larval hostplants, *Cleome ornithopodioides* L. and *Cleome iberica* D.C., in known locations were unsuccessful. Germination of both host-plants appears be triggered by the return of rain, but it is clear that other factors play a key role. Among these, bulldozing of mountain tracks and the associated disturbance of gravelly trackside verges, within which the hostplants have been observed to thrive, appears to assist germination by abrading the seeds and/or in exposing seeds to light stimuli (John *et al*., 2008; John, Makris & Christofides 2013). In the absence of the species' host-plants, it was unsurprising that the pierid was not encountered; indeed, there were no reports at all contributed to the Cyprus Butterfly Recording Scheme (operated by the first author) during the autumn of 2017.

In that period, it was evident from the parched state of known biotopes and the complete disappearance of host-plants, that these areas had not seen any autumn rain. The absence, both of *P. chloridice* and of any history of migration of the species *from* the island, leads us to speculate that pupae resulting from the spring brood had remained in facultative diapause throughout the autumn, to reappear in spring 2018, when *P. chloridice* returned to the wing.

Pupation sites

Little is known about pupation sites in the wild, and in particular in the seemingly unusual mountain biotopes of Cyprus, when elsewhere the species appears to be strongly linked with dry riverbeds (e.g. Anastassíu, Coutsis & Ghavalas 2016). John *et al*. (2008) reported on the unsuccessful searching of hundreds of plants in October 2007 for evidence of pupation sites. Tolman (1992) made an interesting observation, stating 'The pupa is quite remarkable for giving the immediate and striking impression of a bird-dropping – apparently unique in the European Pieridae. This, however, is not so surprising considering the character of the biotope in which the butterfly lives, if it is surmised that pupation occurs on the surface of the same, smooth and rounded stones which harbour its host-plant. This supposition is supported by the absence of alternative pupation sites (within the area containing its host-plant) and the observed behaviour of the males, which, of course, provide the clearest possible indication of the whereabouts of female pupae.'

Whilst the hypothesis relating to selection of pupation sites appears to be based on experience when rearing the species in captivity, it was noted, both by Tolman & Lewington (1997: 42) and Franeta, Kogovšek & Verovnik, 2012 that larvae leave the hostplant in order to pupate. Indeed, Coutsis & Tolman (1996) illustrate a pupa of *P. chloridice* clearly attached to the flat surface of a stone. However, this does not fully conform to the rearing experiences of others. For example, Makris (2003: 113) and Martin Gascoigne-Pees (see Fig. 4 in John *et al*., 2008) each photographed a pupa attached to the host-plant – in both examples, pupation took place in late autumn when, it could be argued, larvae are most likely to leave the host-plant prior to the onset of winter. However, Christodoulos Makris also reported that other *P. chloridice* larvae had pupated on the sides of the container, as had also been the experiences of Peter Russell and David Hall when rearing the pierid (pers. comm. to the first author).

Furthermore, while the use of smooth, rounded stones might sometimes apply in countries where dry riverbeds provide suitable biotopes, this does not appear to hold true in Cyprus, or in the biotope illustrated by Franeta, Kogovšek & Verovnik (2012). In Cyprus, *P. chloridice* is often, although not exclusively, associated with host-plants growing in sharp gravel formed from vesicular basalt dykes in the Tróodos Mountain range (Figs 1–2). The character of the substrate shown in these photographs bears a strong resemblance to the Macedonian biotope illustrated in Franeta, Kogovšek & Verovnik (2012, Fig. 4), even though this formed a riverbed at 60 m elevation. Yet the finding of *P. chloridice* in close attendance with the host-plant in an entirely different biotope – that of a *recently ploughed* olive grove at 570 m (John, Makris & Christofides 2013) – clearly indicates a degree of adaptability of the hostplant to different growing conditions, and demonstrates a high capability of *P. chloridice* in finding such disjunct biotopes.

Facultative pupal diapause?

Although extended pupal diapause in *P. chloridice* is undocumented, an argument in favour of this occurring in southern areas of distribution during prolonged periods of drought, appears compelling. Larsen (1996: 142), for example, referred to the related *P. glauconome*, a desert and sub-desert species colloquially known as the Desert White or Desert Bath White, having the capability of remaining in pupal diapause for perhaps up to six years.

P. chloridice appears to be an opportunistic species, exploiting habitats in Cyprus that are sometimes transient in nature. The absence of any autumn sightings in 2017, coinciding with the disappearance of host-plants from hitherto established biotopes, would seem to support the view that in adverse conditions pupae from the spring brood might remain in diapause until spring of the following year. In 2007, the late Torben Larsen (pers. comm. to first author) wrote of *P. chloridice*, 'there could be very real differences in phenology from year to year. The most logical is that the spring brood results in pupae that (perhaps only partly) aestivate, hatching in autumn in good years and not in bad years. The species might even be able to skip a year if conditions are not right'.

Anastassíu, Coutsis & Ghavalas (2016), reported on a third emergence per year of *P. chloridice* in Greece, in which individuals with either darker or lighter green underside markings were evident in August 2013. Although considered a less likely possibility for the variation in colouring, the authors tentatively hinted at the darker coloration, normally associated with the spring

brood, being associated with the retarded emergence of some individuals, thereby mirroring, somewhat, the remarks of Larsen above and, to a degree, the hypothesis proposed in this paper.

We anticipate that future investigations in Cyprus and perhaps Greece, will confirm the ability of *P. chloridice* to circumvent adverse autumn conditions (which may intensify due to climate change) by remaining in facultative pupal diapause until host-plant regrowth the following spring.

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