

NOTE

First record of the Lime Swallowtail *Papilio demoleus* Linnaeus, 1758 (Lepidoptera, Papilionidae) in Europe

Papilio demoleus (Linnaeus, 1758), the Lime Swallowtail, is one of the most widespread members of the family Papilionidae and one of the most studied butterfly species partly due to the quick expansion of its range and potential danger to agriculture (Eastwood *et al.*, 2006; Goyle, 1990; Mérit *et al.*, 2009; Smith & Vane-Wright, 2008; Wehling *et al.*, 2006; Zakharov *et al.*, 2004). This Indo-Australian species originally had a strongly disjunct distribution. The first part ranged from the Arabian Peninsula in the west through tropical Asia to Okinawa (Japan) in the east (nominate subspecies), and mainland Southeast Asia in the south (ssp. *malayanus* Wallace, 1865). The second part of the range encompassed Australia (ssp. *sthenelus* Macleay, 1826), some of the Lesser Sunda Islands (ssp. *sthenelinus* Rothschild, 1895), and southern Papua New Guinea (ssp. *novoguineensis* Rothschild, 1908). The latter three subspecies are well differentiated in DNA, morphology, and life history (Smith & Vane-Wright, 2008; Zakharov *et al.*, 2004). Most importantly, whereas *Citrus* trees and other members of the Rutaceae family constitute the main hostplants of the Asian populations, the caterpillars in the Australian region only feed on Fabaceae (Cullen), and thus have never been noted as a pest on *Citrus* (Fenner & Lindgren, 1974; Smith & Vane-Wright, 2008; Straatman, 1962; but see Tripathi *et al.*, 1998). No populations were known from the remaining Indo-Australian archipelago, until the species started its expansion into the Philippines in the late 1950s (Smith & Vane-Wright, 2008). During the 1980s and 1990s, *P. demoleus* continued its range expansion across Indonesia, including the Lesser Sunda Islands which were already inhabited by ssp. *sthenelinus* (Matsumoto, 1996; 2002; Moonen, 1991;

1999; Rawlins, 2007; Smith & Vane-Wright, 2008), and reached northern Papua New Guinea in 2004 (Tennent *et al.*, 2011; Wiemers, 2007).

At its western range margin, *P. demoleus* has also extended its range in historical times from Iran into Iraq and around the Persian gulf, following the cultivation of *Citrus* (Larsen, 1977; 1984). In Oman, it occurs now in close proximity to its Afrotropical relative *Papilio demodocus* Esper, 1799, which also feeds on *Citrus* (Clarke *et al.*, 1963; Henning *et al.*, 1997; Larsen & Larsen, 1980). Most recently, *P. demoleus* extended its range further into the Palaearctic Region. In 2003 and 2004, *P. demoleus* appeared in central Syria, near Al Qaryatayn and Palmyra, and shortly afterwards, in 2005, it was recorded for the first time in Turkey, where populations were established in city parks and gardens with lemon trees in Nusaybin city (Mardin Province) close to the Syrian border (Benyamini *et al.*, 2007; Koçak *et al.*, 2006; Koçak & Akdeniz, 2008).

At about the same time, the species was discovered in the New World, where the ssp. *malayanus* was accidentally introduced to the Caribbean (Eastwood *et al.*, 2006). It was first recorded in 2004 from the Dominican Republic on Hispaniola (Guerrero *et al.*, 2004), and since then has spread quickly to the neighboring islands of Puerto Rico, Jamaica, and Cuba (Garraway *et al.*, 2009; Homziak & Homziak, 2006; Lauranzón Meléndez *et al.*, 2011).

Apart from its first appearance in the Caribbean region, most of the range expansion of *Papilio demoleus* appears to be due to immigration and subsequent assimilation at new territories, following corridors of *Citrus* plantations everywhere. Even though this species usually displays stationary behavior, its migratory capabilities are well known from occasional regional migrations which can involve thousands of individuals (Dell, 1977; Dingle *et al.*, 1999; Ramesh *et al.*, 2012; Smithers & McArtney, 1970). The range expansion in the Indo-Australian archipelago was possibly facilitated by deforestation coupled with increased cultivation of *Citrus* and international trade (Smith & Vane-Wright, 2008).

Since the records of the species in Syria and Turkey in 2003-2006, no further range expansion into the Palaearctic region was observed. Until now,

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the record near Al Qaryatayn in Syria (34° 13'N, 37° 14'E) has been known as the westernmost population of the species in Eurasia. This is most interesting, because this Syrian location is a mere 120 km from the Mediterranean Sea, and Nusaybin in Turkey already belongs to the Mediterranean Region, which is one of the largest *Citrus*-producing areas in the world.

On 10 April 2012, the first author found a *P. demoleus* male in Portugal, Algarve, Municipio Loulé, south of Loulé, in the vicinity of Dos Quartos (37°06'33"N, 8°02'18"W). The butterfly was flying in the *Citrus* garden of the villa Quinta Mimosa (Fig. 1). No previous record is known from Portugal or any other European country (Kudrna *et al.*, 2011; Maravalhas, 2003). The first record of this species in Europe, in the western Palaearctic region, is particularly interesting and important, taking into consideration the great distance of more than 4000 km to the previous westernmost locations in Syria (Fig. 2). A natural immigration to the Algarve appears most unlikely due to the long distance to the closest populations and the only minor wing damage of the specimen (but see Fraser, 1946). Furthermore, the collected specimen appears to belong to the subspecies *malayanus* according to wing pattern characters and not to the nominate subspecies which is found in SW Asia. Instead, the species was probably introduced with cultivated *Citrus* or by international trade. In the case of the introduction to the Caribbean it has been speculated that *P. demoleus* was imported for a release at a wedding ceremony, by hobbyists, or that it escaped from a butterfly house (Benyamini *et al.*, 2007; Wehling *et al.*, 2006). As far as we know, there are no butterfly houses in the Algarve region, but some exist in the Lisbon area, at a distance of about 200 km. A genetic study of the European specimen is planned to help reveal its origin.

Further monitoring of the area is necessary to verify whether *P. demoleus* is established in Portugal. It is possible that this record remains a singularity, as was the case with the single specimens of the Afrotropical *Papilio demodocus* which have been found in California (USA) and East Timor during the 1960s (Mendes & Bivar de Sousa, 2010; Tilden, 1968). In April 2012 adverse weather conditions (rains and strong wind) did not allow further observations. A permanent occurrence is not excluded because of the abundance of larval host plants there and suitable climatic conditions. Although the climate is slightly cooler than in Turkey and Syria (with mean annual temperatures of 17.4°C in Faro compared to 18.8°C in Al Qamishli, Syria), the winters in the Algarve area are warmer (with average minimum daily temperatures per month of 7.3°C compared to 2.3°C in Al Qamishli; Fig. 3).



Figure 1. Male of *Papilio demoleus*: Portugal: Algarve: Faro: Loulé: Dos Quartos, 12 April 2012, D. V. Morgun leg.

Until recently, *Papilio demoleus* was thought to be a species confined to warm climates, and that a climatic barrier was limiting its further north-westward expansion from the Arabian Peninsula into the Mediterranean Region. The recent records indicate that *P. demoleus* might be a more adaptive species which can acclimatize in regions with slightly different conditions and colonize the *Citrus* plantations there. Some authors associate the *P. demoleus* range extension with recent climatic warming in the Northern Hemisphere that move the climatic borders previously limiting the species' distribution (Benyamini *et al.*, 2007). In Nusaybin (Turkey), *P. demoleus* was able to survive the winter 2005/2006, even though temperatures dropped below 0°C on two days in February (to -2°C). Compared to the reference period 1961-1990, however, the winter 2005/06 was 2.4°C warmer (Fig. 4), and it remains to be seen if *P. demoleus* populations can survive here. The following winters (apart from the even warmer winter 2009/10) had mean temperatures close to the long-term average. In Syria, the species seems to be well established, as it was recorded again in 2007 and 2010, both times at Dayr Az Zawr (data obtained from www.observado.org). This location is along the Euphrates River, halfway between Palmyra and Nusaybin, and has a very similar climate, especially regarding minimum temperatures in winter (20 annual frost days compared to 16 frost days in Nusaybin).

If *P. demoleus* is able to survive in areas with Mediterranean climate, this could have serious implications for the *Citrus* industry in the

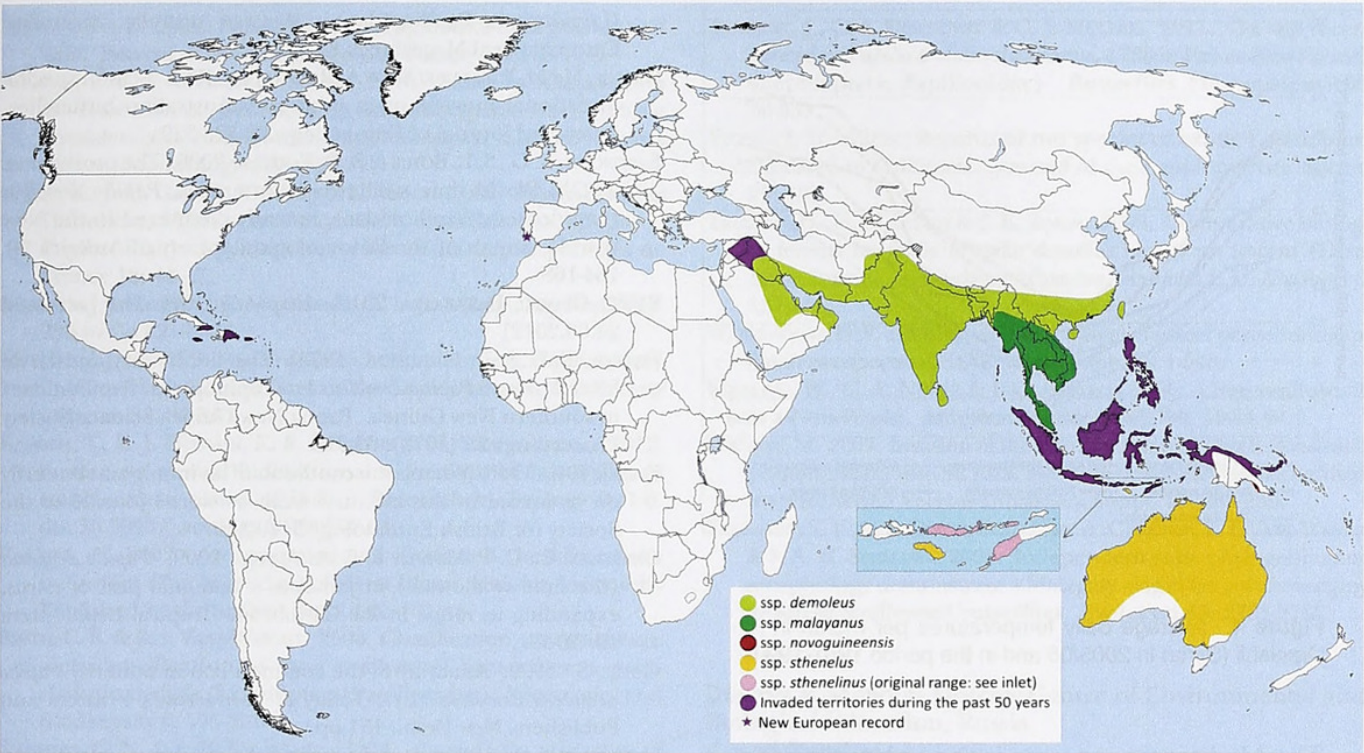


Figure 2. Distribution of *Papilio demoleus*. The inlet shows the distribution of *Papilio demoleus* in the Lesser Sunda Islands before the invasion from SE Asia (i.e. 1990). Last records of ssp. *sthenelus* currently known to us are from 1988 (Alor), 1992 (Timor), and 1997 (Komodo). First records of invasive populations in the Lesser Sunda Islands are from 1990 (Sumbawa), 1991 (Lombok), 1993 (Timor), 1995 (Leti), 1997 (Flores), 2002 (Wetar), and 2007 (Alor).

Mediterranean region. Larvae of *P. demoleus* can entirely defoliate orange and lemon trees, especially young trees, and populations can proliferate and disperse quickly. In most of its range the species has 4-6 generations per year. In Iran, the complete life cycle only takes about 33-35 days (Abivardi, 2001).

An example of another *Citrus*-feeding lepidopteran species with South Asian origin which has greatly expanded its range in recent decades is the Citrus Leafminer, *Phyllocnistis citrella* Stainton, 1856 (Gracillariidae). It is now a pest in all major *Citrus*-growing areas of the world, including the Mediterranean region, most of Africa, the Americas, New Guinea and Australia (De Prins & De Prins, 2012; EPPO, 2012; Hoy & Nguyen, 1997; Waterhouse, 1998). It even managed to reach many remote islands and archipelagos such as Guam, Samoa, Mauritius (1995), Micronesia (1996), the Azores (1997), Bermuda (1998), Hawaii (2000), and Galapagos (2005). *P. citrella* spread with a remarkable speed: Since its discovery in Florida in 1993, it took only 3 years for its expansion into most American countries from the Southern USA via Central America and the Caribbean to Argentina, and during the same time period all Mediterranean countries were colonized as well.

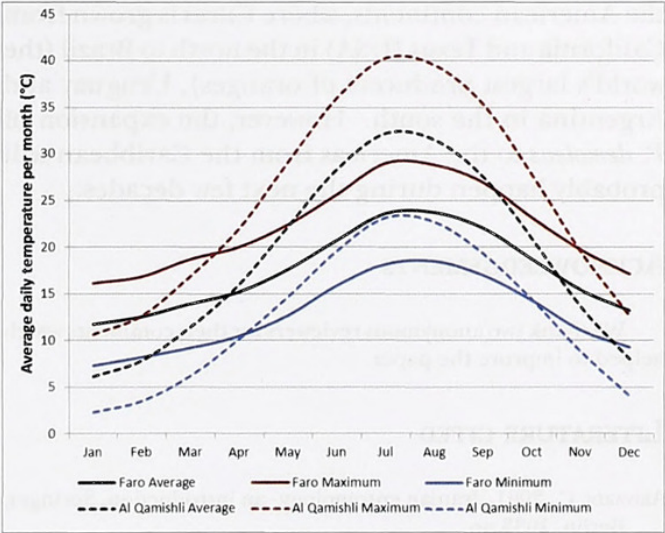


Figure 3. Average daily temperatures per month in Faro (Portugal) and Al Qamishli (Syria) in the period 1961-1990.

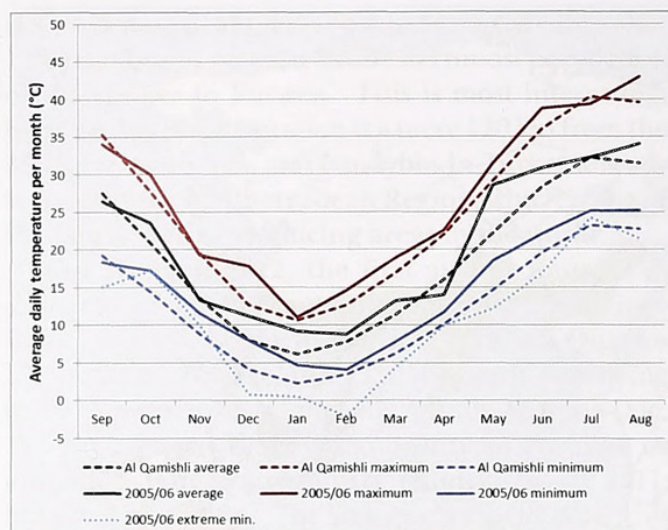


Figure 4. Average daily temperatures per month in Al Qamishli (Syria) in 2005/06 and in the period 1961-1990.

The Mediterranean area is the only major *Citrus*-growing region in the world which is not yet inhabited by a *Citrus*-feeding *Papilio* species. Therefore it would be potentially important to know whether *Papilio demoleus* is able to establish here. The only major *Citrus* production areas which have not yet been invaded by *P. demoleus* are the Afrotropical Region, which is already inhabited by *Papilio demodocus*, and the American continents, where *Citrus* is grown from California and Texas (USA) in the north to Brazil (the world's largest producers of oranges), Uruguay and Argentina in the south. However, the expansion of *P. demoleus* to the Americas from the Caribbean will probably happen during the next few decades.

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