

### Research article

Submitted: November 18<sup>th</sup>, 2021 – Accepted: November 8<sup>th</sup>, 2022 – Published: December 15<sup>th</sup>, 2022  
DOI: 10.13133/2284-4880/1398

## An exceptional influx and successful breeding of *Pantala flavescens* on the Island of Malta (Maltese Archipelago) (Odonata: Libellulidae)

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### Abstract

*Pantala flavescens* (Fabricius 1798) appeared in unprecedented numbers in summer and autumn 2020 on the island of Malta. Several males were observed holding territory over largely bare, small bodies of water, mostly at Chadwick Lakes and Fiddien. Breeding activity was witnessed several times and 128 exuviae were found of which 124 were collected.

**Key words:** *Pantala flavescens*, Europe, influx, Chadwick Lakes, Fiddien, exuvia, teneral.

### Introduction

*Pantala flavescens* is a common, circumpolar species often abundant in the tropics and subtropics of both the Old and New World. It is a migratory species in most parts of its range, appearing in huge swarms along the monsoon fronts (Kalkman & Monnerat 2015). It is an example of obligate nomads of the Inter-Tropical Convergence Zone that oviposit in ephemeral rainwater pools in otherwise arid areas and that, as adults, travel long distances to reach new reproductive sites (Corbet 1999). The species regularly crosses the Indian Ocean, reaching the Maldives in swarms involving millions of individuals and later arriving in east Africa. Isotope studies suggest that these populations originate from the northern Indian subcontinent, or even beyond, and move on to east Africa before flying back to their point of origin, a journey that involves at least four generations (Hobson et al. 2012). In a study involving the use of stable isotopes of hydrogen to try to determine the origin of *P. flavescens* migrating to and breeding in Middle Asia, Borisov et al. (2020) came to the conclusion that the species has a probable extensive migration circle covering East Africa, Central Asia and the Indian subcontinent covering a total of more than 14,000 km. The species is common in North America but is sparsely recorded in the northernmost states (Paulson 2011). It has also reached Easter Island in the SE Pacific where it exhibits peculiar life history adaptations (Dumont & Verschuren 1991).

Although *P. flavescens* is common and widespread in sub-Saharan Africa it is rare in the North African states, only infrequently recorded at the north-western edge of the Sahara since the mid-1990s with just a handful of sites in Morocco and Tunisia (Boudot et al. 2009; Dijkstra et al. 2020). At least 20 individuals were, however, seen on the island of Djerba, Tunisia on 30 Sep 2010 (Corso et al. 2017). The species is one of the rarest dragonfly species observed in Europe and details of known records from this region are given in Kalkman & Monnerat (2015). The only instance of suspected breeding refers to a female in late teneral condition in 2001 in Rhodes (Laister 2005).

In more recent years sightings in Europe have increased significantly, especially in the Mediterranean, and the species is now listed as scarce, although still rare in the western section (Dijkstra et al. 2020). Most of these sightings come from the Italian islands in the Sicilian Channel and from Cyprus, both in numbers and frequency. In Italy the species has been recorded in 2012 from the islands of Linosa and Lampedusa, on Linosa in 2012, 2014, 2015 and 2016. In Sicily *P. flavescens* was observed in 2012, 2014, 2016 and 2018, but no breeding behaviour was observed (Corso et al. 2012; Corso et al. 2017; Galasso et al. 2020). On mainland Italy a female was photographed in the region of Piemonte in the north-west on 14<sup>th</sup> August 2019 (Piretta & Assandri 2019). In Cyprus the species was first recorded in 1957 and then in 2010. Widespread observations following the founding of the Cyprus Dragonfly Study Group in

2012, led to the species being recorded annually from 2013 to 2019 during which period breeding activity was recorded in most years and included a larva in 2018.

In 2019 breeding was confirmed in Switzerland when an immature male was recorded at Holderbank (Canton of Aargau) on 23<sup>rd</sup> August, followed by the discovery of an exuvia at the same place on 4<sup>th</sup> September (Henseler et al. 2019) and in Germany, when an exuvia and a post- teneral were found on 17<sup>th</sup> August in the south-east area of Brandenburg, at the same place where a mature male had been seen on 6<sup>th</sup> July (Günther 2019a, b). In 2020 the species was found breeding in Poland when 3 teneral males were seen on their maiden flight at Lake Rakutovskie in the central part of the country on 12<sup>th</sup> August (Levandovska et al. 2020).

Prior to 2020 *P. flavescens* had been recorded on the Island of Malta seven times. It was first recorded in 2013 with 3 individuals (Degabriele 2013). A male was seen at Dingli Cliffs in 2014 (Gauci 2018). In 2019 a male and female were seen at Imselliet Valley (Gauci 2019) and a male at Chadwick Lakes (Piretta & Assandri 2019).

## Material and methods

In 2020, following the sighting of a male *P. flavescens* at Chadwick Lakes 35.53.31N, 14.23.25E on 29<sup>th</sup> July, this site, together with Fiddien 35.53.12N, 14.23.11E, which forms part of the same valley system consisting of artificial reservoirs with a system of dams, was visited on most days until the end of November. A section of Chadwick Lakes and Fiddien, which had become badly silted up over the years, had been re-excavated during the summer months in 2019, as a result of which some sections held a little water throughout the summer of 2020. For observation purposes Chadwick Lakes was divided into three sections: main reservoir (Fig. 1), inner reservoir (Fig. 2) and the middle section in between. The main reservoir held some water in two sections, the inner reservoir held water in one section but was gradually reduced to a number of puddles as water was pumped during the summer months. Both were largely bare of any vegetation. The middle section initially held a fairly large pool, again devoid of any vegetation which, like the inner reservoir, was gradually reduced to a series of bare puddles, and a vegetated stretch with some visible puddles. In the dry summer months the valley section at Fiddien consists of a 1m deep pool which is pumped for irrigation and, following excavation in late spring 2020, a puddle (Fig. 3) next to it. This puddle, which when full had a surface area of about 4x4m and a depth varying between 5 and 25cm, seemed to have filled up with water seeping from the fields above it. After the first heavy rains a number of other sizeable puddles formed, but these soon dried up. Other sites occasionally visited were Imselliet Valley 35.55.12N, 14.23.58E,

Wied Rihana 35.55.59N, 14.25.14E, Salina 35.56.38N, 14.25.09E and Ta' Qali 35.53.36N; 14.25.02E. Imselliet Valley consists of a series of narrow dammed reservoirs which, with the exception of one, have both sides lined with *Arundo donax*. Wied Rihana is another dammed valley system, but much more open than Imselliet, while the area of observation at Ta' Qali consists of a large, deep concrete reservoir.

Between 29<sup>th</sup> July and 27<sup>th</sup> November, when the first and last *P. flavescens* were seen, observations were carried out at Chadwick Lakes and Fiddien on 84 days. The days that were missed were due to visits to the other sites to check for the presence of the species or, in the latter part of the observation period, due to inclement weather involving prolonged periods of rain during the day.

Visits were mainly conducted in the morning, each visit lasting between 2 and 3 hours, usually starting at 0900 CEST and finishing at around noon. Twelve visits were also made in the afternoon, each lasting up to two hours and the time of day varying between 1300 and 1715 CEST. Visits consisted of a walk of about 2 km and back along the narrow valley system, with 15 minute observation stops near each water body. Besides counting the odonata present, with special attention being focused on *P. flavescens*, breeding activity and other behaviour was also recorded. Photos were taken when conditions and time permitted. In recording reproductive behaviour, besides numbers of pairs seen in copula, mode of guarded (or, sometimes unguarded) oviposition and duration, the preferred oviposition sites were also noted. After the first exuviae were found on 9<sup>th</sup> October a daily check was kept for fresh exuviae up to the end of November and twice weekly in December. At the beginning of August bird watching friends were alerted to the presence of *P. flavescens*, briefed about the species, and urged to report any sightings.

Due to difficulties in accessing the shoreline, other than at the Fiddien puddle, it was not possible to search for exuviae at all three sections of Chadwick Lakes.

## Results

In 2020 *P. flavescens* imagos were noted present in the Maltese Islands from 29<sup>th</sup> July to 27<sup>th</sup> November. Most were seen at the valley system of Fiddien and Chadwick Lakes where the bulk of the daily observations were carried out. Others were recorded from Imselliet Valley, Wied Rihana, Salina, Ghadira Nature Reserve, Rabat and at a small, newly constructed pond at Wied Dalam. At Chadwick Lakes and Fiddien a maximum of 8 individuals were recorded up to 18<sup>th</sup> September. The following day 7 were seen flying low over the coastal saline lagoon at Ghadira Nature Reserve. An influx of migrant dragonflies had apparently taken place on that day as at the same site over 20 *Anax parthenope* and 50 *Sympetrum fonscolombii* were present in the early part

**Table 1** – Reproductive behaviour of *Pantala flavescens* in the Maltese Islands in 2020.

Date	Time of day	Site	Behaviour	Oviposition type
19 Aug	am	Chadwick (mid)	oviposition	tandem
23 Aug	am	Chadwick (mid)	oviposition	tandem/NCG
27 Aug	pm	Fiddien (puddle)	oviposition	unguarded
8 Sep	am	Fiddien	copula	-
9 Sep	pm	Fiddien (puddle)	presumed ovip.	unguarded*
17 Sep	am	Fiddien (puddle)	oviposition	tandem
20 Sep	am	Fiddien (puddle)	presumed ovip.	unguarded*
21 Sep	am	Fiddien (rain p.)	copula	-
28 Sep	am	Salina	oviposition	unguarded
6 Oct	am	Fiddien (rain p.)	copula	-
7 Oct	am	Chadwick (mid)	oviposition	tandem
10 Oct	am	Fiddien (puddle)	oviposition	tandem
11 Oct	am	Fiddien (puddle)	oviposition	unguarded
14 Oct	am	Fiddien (puddle)	oviposition	unguarded
16 Oct	am	Chadwick (mid)	attempted ovip.	unguarded**
16 Oct	am	Chadwick (inner)	oviposition	tandem
17 Oct	am	Chadwick (inner)	copula/ovip.	tandem/NCG
20 Oct	am	Fiddien (puddle)	oviposition	unguarded
20 Oct	am	Chadwick (mid)	attempted ovip.	unguarded**
22 Oct	am	Chadwick (dry)	copula	-
29 Oct	am	Chadwick (mid)	oviposition	unguarded
9 Nov	am	Chadwick (inner)	copula/ovip.	unguarded
11 Nov	am	Chadwick (inner)	copula/ovip.	tandem
11 Nov	am	Chadwick (inner)	oviposition	unguarded
12 Nov	am	Fiddien (puddle)	oviposition	unguarded
18 Nov	am	Fiddien (rain p.)	oviposition	unguarded
18 Nov	am	Wied Dalam	oviposition	unguarded

\*female flying over puddle on arrival but oviposition not witnessed. \*\*female twice tried to oviposit but left following attempted hooking up by 2 males. NCG= non-contact guarding; mid = middle section; inner = Inner section; rain p. = rain puddle.

of the day. Due to time restrictions it was not possible to visit Chadwick Lakes/Fiddien on the same day. However, on the following day, 20<sup>th</sup> September, 20+ (1 female, rest males) *P. flavescens* were counted at Chadwick Lakes/Fiddien in the morning and 16 (all males) in the afternoon at Wied Rihana. Another male was reported from Imselliet Valley. On the same day other migrant dragonflies were again very much in evidence, e.g. 80+ *A. parthenope*, 8 *A. ephippiger* and 100+ *S. fonscolombii* at Wied Rihana. Numbers of *P. flavescens* went down again to mostly single figures from 23<sup>rd</sup> September but shot up once more on 6<sup>th</sup> October, when 23 counted. Numbers then remained into the low double figures until 26<sup>th</sup> October. Following a rainy morning and cloudy afternoon with a strong wind on 27<sup>th</sup> October, and a gale force wind on the following day, numbers went down drastically and the number of mature individuals seen never exceeded 5 (Fig. 4).

Nearly all males seen were holding territory but 3 and 2 males were seen hunting insects over a fallow field in the shelter of *Arundo donax* stands in late afternoon at Fiddien. At the main and inner reservoirs, as well as at the pool in the middle section of Chadwick Lakes, a male would hold territory at each end. After the first heavy rains other males held territory over temporary puddles while others patrolled sections of the dirt road/path running alongside when all territories over water had been occupied. Males would incessantly fly to and fro over a territory covering an average length of 20m and would mostly fly at an average height of 1m, sometimes interacting with both *A. imperator* and *A. parthenope* which were holding territory and flying the same trajectory as them. Occasionally they were seen chasing *Trithemis annulata* males which would fly beneath them. No interaction was noted with other anisoptera species regularly present – *Orthetrum cancellatum*, *O.*





**Fig. 1** – The main reservoir at Chadwick Lakes in late September, 2020.

*trinacria*, *Crocothemis erythraea* and *Selysiothemis nigra*. However, a male holding territory over the puddle at Fiddien was noted persistently mobbing three *Sympetrum fonscolombii* tandems which were ovipositing close together. Territorial males were also observed harassing conspecific ovipositing tandems. Males were only found perched on four occasions (Fig. 5).

Breeding behaviour was recorded 27 times and, except for two instances, always at the Chadwick Lakes/Fiddien valley system. The first sign of reproductive activity was observed on 19<sup>th</sup> August when a tandem was found ovipositing in a group of puddles in the middle section of Chadwick Lakes. Thereafter breeding behaviour, including a number of pairs in copula (Fig. 6), was observed during most visits, as listed in Table 1 and the last oviposition at the main sites investigated was observed on 18<sup>th</sup> November. Additionally, on 27<sup>th</sup> November a female was observed ovipositing at the newly constructed artificial pond at Wied Dalam (P. Portelli, pers.com).

The preferred sites for oviposition were always small, generally drying out, puddles which formed when the main water bodies were drying out, or newly formed rain puddles. Ovipositing females (both unguarded or in tandem)

preferred to deposit eggs very close to the shoreline while flying continually around the water body and dipping their abdomen in the water. In the middle section of Chadwick Lakes the puddles dried out within a few days after oviposition as water was being pumped daily.

On 9<sup>th</sup> October at 1000 CEST, upon arrival at the Fiddien puddle where a female was first seen ovipositing on 27<sup>th</sup> August, 5 teneral were seen flying off from the puddle and another one was found with damaged wings rendering it unable to fly. Upon close inspection 25 exuviae, 5 of which did not appear to be fresh, were found and collected. This puddle had gradually dried out between 1<sup>st</sup> and 6<sup>th</sup> September, although the bottom sediment was still wet. It started filling up again on 7<sup>th</sup>. On 10<sup>th</sup> October at the same time as the day before, two teneral were seen flying away and another 23 fresh exuviae were found and collected. On 11<sup>th</sup> October at 0900 CEST 6 teneral were seen flying away or still resting on the exuvia (Fig. 7), 17 fresh exuviae were found and collected, and two final instar larvae were seen. Emergence then continued on most days, with intermittent stops during periods of adverse weather (rain and cool, strong winds) until the last exuviae were found on 18<sup>th</sup> November (Fig. 8). On 6<sup>th</sup> November at the inner



reservoir at Chadwick Lakes a fresh set of teneral wings was found on the shoreline, probably as a result of avian predation by one of the *Motacilla alba* present daily at the site. Wagtails have been frequently seen feeding on odonate tenerals at Ghadira Nature Reserve (Gauci 2020) as well as at other sites (pers. obs.).

All exuviae were found at heights varying between 10cm and 30cm. A little casual pond dipping consisting of five swipes along the bottom sediment with a 15x12cm net at the Fiddien puddle on 23<sup>rd</sup> November produced a *P. flavescens* larva about 1/3 grown.

## Discussion

*Pantala flavescens* has in recent years been sighted more frequently in Europe (Kalkman & Monnerat 2015; Piretta & Assandri 2019) and it has been tentatively suggested that this might be due to an increase in the number of observers in many countries. Annual observations on the Italian Pelagie Islands in autumn have been ongoing since 2003 but it was only in 2012 that the first *P. flavescens* were recorded (Corso et al. 2017). Sparrow et al. (2020) concluded that this could not be the reason for the increase in sightings in Cyprus as constant monitoring at a number of sites had been going on since 2012 and it was only in 2018-19 that a significant increase in numbers had been recorded. The same reasoning applies to the Maltese Islands where extensive odonate observations have been carried out annually on a daily basis throughout the flight season (March to November) since 2009. However, locally no observations have been carried along the coast for migrating dragonflies although *Anax ephippiger* has, on several instances, been reported by birdwatching friends. In Cyprus *P. flavescens* numbers have been seen migrating north, but a return migration has never been witnessed (Sparrow et al. 2020). In Malta in 2020 the number of sightings totaled 532 of which 28 were females, 31 tenerals on maiden flight, 2 immatures/females, and the rest mature males. Some males were undoubtedly present on more than one day as most of those seen were holding territory. While photographic evidence showed that males seen holding respective territories were not always the same as in previous days it is impossible to quantify the actual number of individuals involved.

*P. flavescens* reproduces at all kinds of standing water but is most successful at small and warm, often temporary, waters with little or no vegetation (Kalkman & Monnerat 2015). In India paddy fields with exposed water surfaces were found to be preferred to fields with crop cover (Chitra et al. 2002). In Cyprus oviposition has been witnessed several times in swimming pools (Sparrow et al. 2020). There is no doubt that in the Maltese Islands the species was attracted to the Chadwick Lakes/Fiddien valley system as a



Fig. 2 – The inner reservoir at Chadwick Lakes in early November, 2020.



Fig. 3 – The Fiddien puddle in early October, 2020 (from where nearly all exuviae were collected).

result of the excavation works carried out in the previous year. For several years prior to 2020 the reservoirs in this valley used to be completely dry by the end of May. In 2020, despite pumping for irrigation, a number of pockets with shallow water, largely devoid of any vegetation, remained throughout summer creating the ideal conditions this species prefers for reproduction. The Fiddien puddle, where successful emergence was recorded, had also dried up for a few days at the beginning of September but the bottom mud was still moist in the deeper part. *Pantala flavescens* larvae have been found to survive desiccation; a larva which was collected by chance with dry mud from the bed of a pond in north-east Brazil was noticed in an aquarium about seven days after the mud first had been wetted. The mud had been dry for several months (Van Damme & Dumont 1999).

In the Maltese Islands agricultural cisterns, usually filled with pumped ground water, and which are used for irrigation, are quite common. Considering the fact that *Pantala flavescens* readily oviposits in swimming pools (Sparrow et al. 2020) and concrete basins (Kalkman & Monnerat 2015) and the lack of observers in the Maltese Islands, it could be possible that oviposition and emergence had also taken place in some of these.

Other than those seen leaving the emergence site on their maiden flight no teneral or post teneral were seen. Migration is thought to start in early post-teneral stage (Corbet 1999). Most teneral seen leaving on their maiden flight from the Fiddien puddle flew a relatively long distance and were lost out of sight either as they flew up to an olive grove on one side or up to a vineyard on the other. Teneral which emerged during the peak emergence period of 9-11<sup>th</sup> October would have been likely to reach sexual maturity and returned to the breeding sites on around

25<sup>th</sup> October. This would be about the time when sightings went down to low single figures, rendering likely the hypothesis that the generation produced from the Fiddien puddle had migrated.

Laboratory controlled experiments showed that eggs failed to hatch at 15°C while at temperatures of 30-35°C eggs hatched after 5 days and at temperatures of 20°C the eggs hatched after 15-16 days. In other laboratory trials the time taken between oviposition and emergence at a temperature of 28-32°C is 56-61 days (Ichikawa et al. 2017;

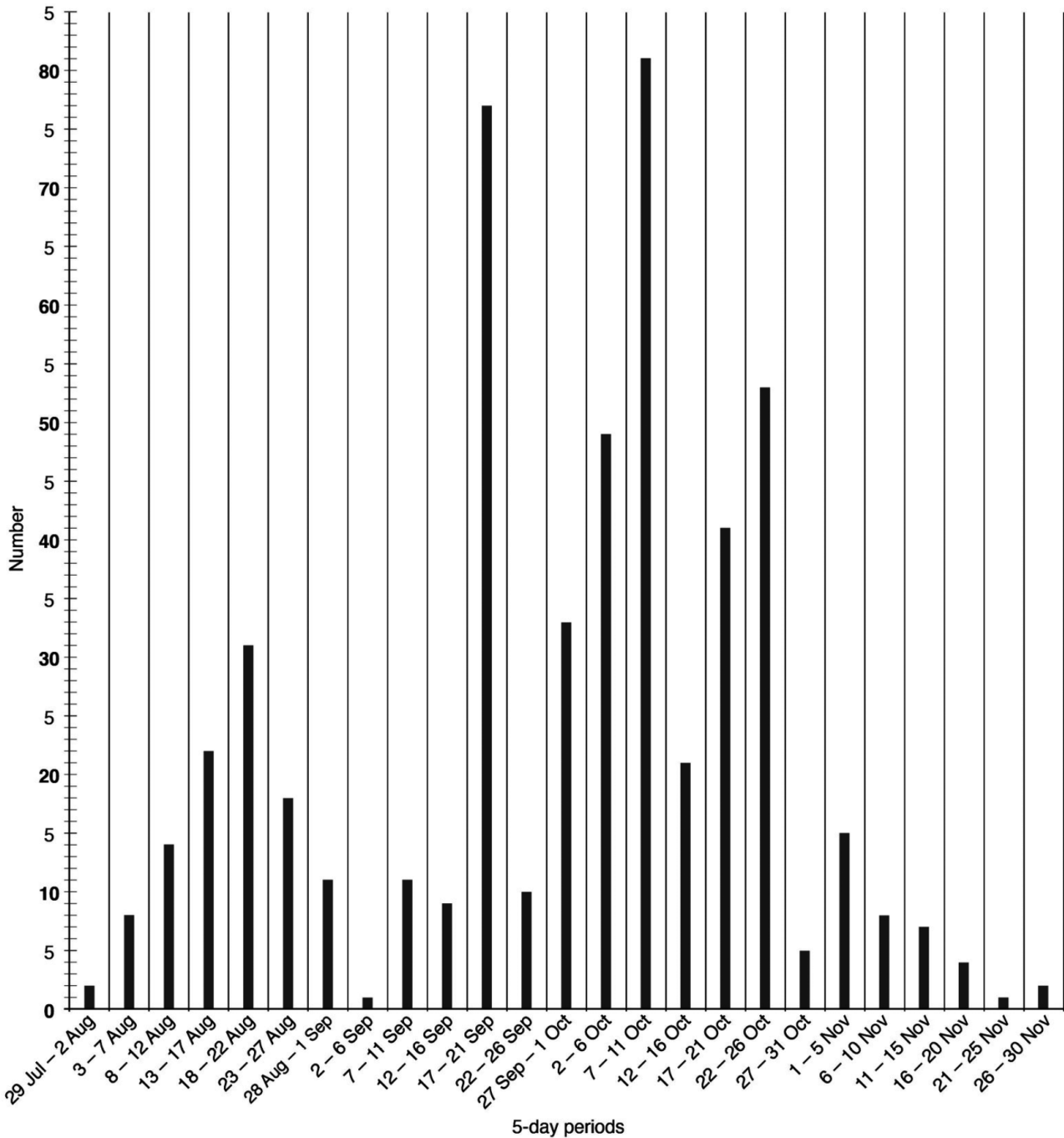


Fig. 4 – Numbers of *Pantala flavescens* recorded in the Maltese Islands between 29<sup>th</sup> July and 27<sup>th</sup> November, 2020.





Fig. 5 – Male at rest at Fiddien in late September, 2020.

Kumar 1984). In fish farm ponds at the southern edge of the species' range in Australia *P. flavescens* completed egg and larval development in less than 51 days at temperatures slightly lower than Kumar's (Hawking & Ingram 1994). Maximum air temperature in October in the Maltese Islands varied between 22°C in the early part of the month to 20°C in the latter part; 18-19°C in November; and 16-17°C in December. Early morning water temperature was only recorded in December and varied between 13.5-14°C. It is thus safe to presume that eggs laid in the Maltese Islands after mid-November and, possibly, even earlier in the same month would have failed to hatch.

The most likely provenance of *P. flavescens* arriving in Cyprus is from along the Nile Valley in Egypt (Sparrow et al. 2020) where the species is present all year round and where swarms are more frequently observed between May and January (Kalkman & Monnerat 2015). Although the rarity of this species in the western side of Europe has been largely attributed to the Sahara desert acting as a barrier cutting off the Maghreb from the continent's interior, and with dry winds in the area being unfavourable for dragonfly migration (Buczyński et al. 2014, 2019), the recent increase in records in the central and western Mediterranean suggests that this may not be the case (Piretti & Assandri 2019). The appearance of relatively large numbers in the Maltese Islands in 2020 lends support to this hypothesis.

The same authors also postulated that some individuals arriving in Europe in spring might be able to complete their reproductive cycle and as a result some of the sightings reported in summer and autumn might be the offspring of early spring migrants. The female *P. flavescens* photographed by one of the authors in the Piemonte region of NW Italy is clearly in its early post-tenal stage, having a pale eye colour, pale abdomen as well as pale pterostigma. It was found in a dry area but with several temporary ditches and some small rain pools in the vicinity. Such temporary habitats, which are the preferred sites for reproduction by *P. flavescens*, do not usually attract the attention of dragonfly lovers. Indeed, while the sighting in NW Italy was a casual encounter, the findings of males, teneral and/or exuviae in Germany and Switzerland in 2019 and Poland in 2020 resulted from odonatan surveys at the respective sites (Günther 2019a, b; Henseler et al. 2019; Levandovska et al. 2020).

## Conclusions

While the recent increase in sightings and/or breeding records of *P. flavescens* in small islands such as Malta, Cyprus, Sicily and the Italian islands in the Sicilian Channel (Degabriele 2013; Gauci 2018, 2019; Piretti & Assandri

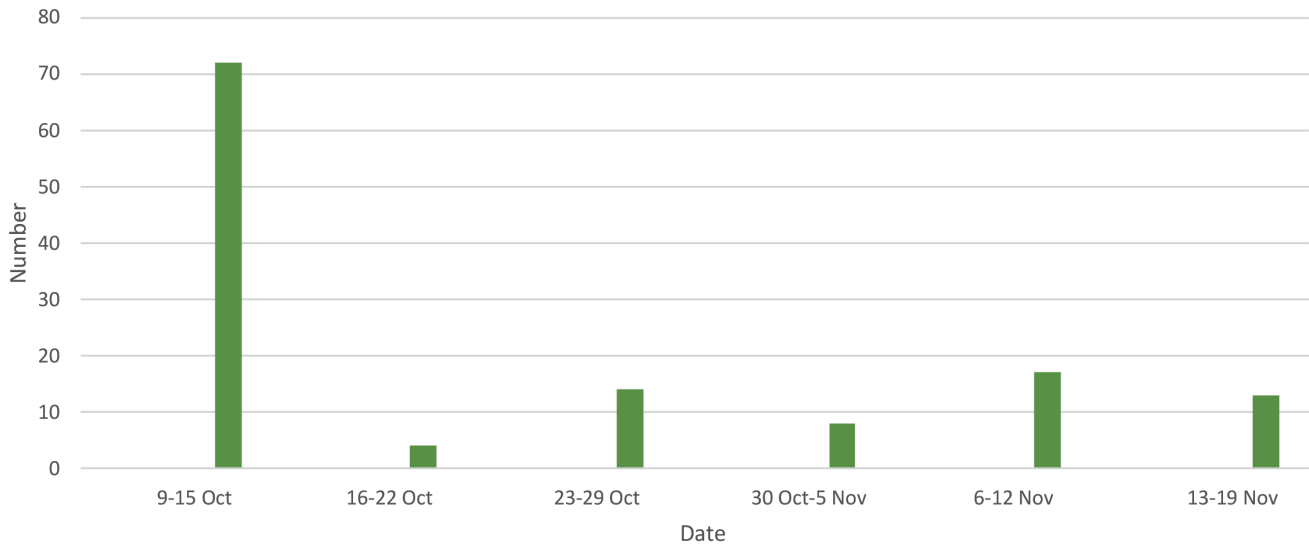


**Fig. 6** – Pair copula over Fiddien puddle on 17<sup>th</sup> October, 2020.



**Fig. 7** – Teneral and exuvia at Fiddien puddle on 11<sup>th</sup> October, 2020.





**Fig. 8** – Number of exuviae found during 2020.

2019; Corso et al. 2017; Galasso et al. 2020) cannot be attributed to an increase in watching activity, it is quite likely that this might be the case in much larger countries. Moreover it is likely that should more attention be given to small, ephemeral sites with scant vegetation in Europe from late spring it might likely yield more breeding records. Only time will tell whether *P. flavescens* will establish itself as a regular breeding summer visitor to the Maltese Islands.

### Addenda

The Maltese Islands experienced a severe drought in 2021, with no significant rainfall between mid-January and a good part of September. In 2021 there were only 14 *P. flavescens* sightings between 14<sup>th</sup> September and 13<sup>th</sup> October, all at Chadwick Lakes and Wied Rihana. All sightings were of males, except for one female on 5<sup>th</sup> October. No breeding behaviour was observed.

There were no sightings in 2022.

**Acknowledgements** – I would like to thank David Attard, Denis Cachia, Mark Gauci and Dr. Paul Portelli who reported sightings. My thanks also go to David Sparrow from the Cyprus Dragonfly Study Group for useful discussion. I am grateful to Victor Falzon for his help with Figure 4. Finally my thanks go to the anonymous referee for his useful suggestions.

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