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Observations of dragonflies (Odonata) from northern Cyprus

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Abstract

During observations by two resident observers in northern Cyprus from June 2003 to September 2004 21 species of dragonfly were recorded. These included nine species not previously recorded from the north of the island, two of which, *Erythromma viridulum* and *Trithemis arteriosa*, were not previously mentioned in the island's literature; the former being a new species for the island. These observations were the first long-term observations on the island and were made during a period of rapid climate and habitat change; the results for *Diplacodes lefebvrii*, *Anax parthenope*, *Orthetrum chrysostigma*, *O. sabina*, *Selysiothemis nigra*, *T. annulata*, and *T. arteriosa* appear to reflect these environmental changes. Other significant records include: *Lestes macrostigma* (early records and migration/dispersal), *Sympecma fusca* (early records), *Erythromma lindenii* (recorded in only one previous year), *A. ephippiger* (mass migration) and *Sympetrum striolatum* (winter mating and ovipositing). Thirty two of the wetlands/water bodies we monitored were not mentioned in the earlier literature. The composition of the island's dragonfly fauna is discussed in relation to island biogeography, climate, and habitat diversity. It is suggested that the low species richness and the narrow species range are due to island biogeographical factors, particularly (in the case of the latter) to the island's poor habitat diversity; and that the surprising absence of endemics may be due to the island's aridity and recurrent drought year clusters. From this it is further suggested that the fauna may be relatively high in species which are quick to colonise and which have generalist habitat preferences.

Zusammenfassung

Libellenbeobachtungen in Nordzypern (Odonata) – Im Nordteil der Insel wurden zwischen Juni 2003 und September 2004 durch zwei auf Zypern residierende Naturkundler 21 Libellenarten festgestellt. Neun Arten waren neu für den Nordteil der Insel, zwei davon, *Erythromma viridulum* und *Trithemis arteriosa*, waren seinerzeit Erstnachweise für Zypern. Bei den Untersuchungen handelte es sich um die ersten intensiven Libellenerfassungen auf Zypern, sie fielen in eine Periode eines drastischen Klima- und Habitatwandels. Die Funde von *Diplacodes lefebvrii, Anax parthenope*, *Orthetrum chrysostigma*, *O. sabina*, *Selysiothemis nigra*, *T. annulata* und *T. arteriosa* sind in diesem Zusammenhang von besonderer Bedeutung. Weitere bedeutende Funde betreffen *Lestes macrostigma* (phäno-

logisch frühe Funde und Meldungen von Wanderung/Dispersal), *Sympecma fusca* (Phänologie), *Erythromma lindenii* (zweiter Nachweis), *A. ephippiger* (Massenwanderung) und *Sympetrum striolatum* (Winterreproduktion). Von 32 Gewässern/Feuchtgebieten wurden erstmals Daten vorgestellt. Die Libellenfauna von Zypern wird mit Bezug auf Inselbiogeographie, Klima und Habitatvielfalt diskutiert. Es ist anzunehmen, dass die geringe Artenvielfalt und kleinräumige Verbreitung bestimmt wird durch inselbiogeographische Faktoren, insbesondere in der geringen Habitatdiversität auf Zypern. Es überrascht einerseits, dass es auf Zypern keine endemischem Libellen gibt, andererseits sind die generelle Trockenheit bzw. über mehrere Jahre anhaltende Trockenheitsperioden für die Insel typisch. Unter diesen Gesichtspunkten ist die Libellenfauna relativ artenreich und insbesondere reich an Erstbesiedlern mit breiter Habitatpräferenz.

Introduction

Cyprus is the third largest island in the Mediterranean with an area of 9251 km^2. It lies in the north-eastern corner of the eastern basin of that sea. The shortest distances to the neighbouring continental mainlands are: to the North 69 km to Turkey, to the East 105 km to the Levant and to the South-Southwest 370 km to North Africa. Physically the island is dominated by the Troodos massif, a large igneous mountain range (maximum elevation 1,952 m a.s.l.) with seasonal rivers and perennial streams, which with its surrounding hills occupies the southwest of the island. In the north the Kyrenia mountains form a long, narrow, low sedimentary ridge (mainly < 800 m a.s.l.) parallel with and just inland from the north coast. The topography and often porous, fractured strata of the northern range mean that it lacks perennial streams (Dreghorn 1978; Geological Department 2018). These two mountain ranges are separated by a central plain (the Mesaoria), widest and lowest in the east. Since 1974 there has been a de-facto division of the island into a Turkish-Cypriot North and a Greek-Cypriot South. Access by visitors to the northern part was limited until 2004 resulting in no previously published dragonfly studies there until 2012, and observer coverage there is still poorer than in the south.

Cyprus has an extreme Mediterranean climate with long, hot, rainless summers and cool, rainy, changeable winters. Average annual temperatures are rising, with a faster rate of increase since the 1970s (Department of Meteorology 2018a). Compared with 1901–1930, mean temperatures in 1991–2016 were 1.0°C higher in winter and 1.5°C higher in summer (CCKP 2018). There was a generally larger increase in average minimum temperatures, by (depending on location) 0.7–1.6°C in winter and 2.2–4.5°C in summer, resulting in reduced diurnal temperature ranges (Price et al. 1999).

Rainfall varies with relief and altitude, thus highest on Troodos, lower in the Kyrenia range and lowest on the Mesaoria. The island's annual rainfall total often varies greatly, with both extremely wet and severe drought years occurring. Average annual rainfall has declined 17% since 1970 (Rossel 2001). This has

increased the frequency of drought/severe drought years which during 1971–2017 occurred on average once every four years, compared with once every seven years 1901–1970. At the same time very high and extremely high rainfall years declined from on average once every 3.5 years 1901–1970 to once every 12 years since then (calculated from Department of Meteorology 2018a). This rapid climate change – lower rainfall and higher temperatures – is making the island more arid.

This aridity means that the few rivers, natural marshes, and lakes are seasonal not permanent. Limited construction of small modern dams began in the late 1940s and greatly increased during and since the 1970s: total dam reservoir water capacity (million m^3) increased from 6 in 1960, to 65 in 1981, to 307 in 2002, with the largest increase in the late 1980s. Currently there are at least 107 large and small modern dams, not including recent small dams in the North of the island (Water Development Department 2009, 2017) though many dry out in consecutive drought years. Additional recent and more permanent artificial water bodies are the sewage farms/water treatment works and the now many agricultural tanks/farm ponds (Sparrow et al. 2016, C. Richardson pers. comm.).

Looking at the existing literature on the Cyprus dragonfly fauna a thorough, comprehensive and authoritative overview was compiled by Lopau & Adena (2002). This was based on the earlier literature; on the authors' own observations at 47 localities in the South of the island early June–early July 1994; on previously unpublished observations by seven other visitors at a total of 20 localities in the South on unspecified dates in 1983/84 and mid-March to mid-April 2000/01, and on the examination by Vincent Kalkman and Gert-Jan van Pelt of 258 specimens dated 1930–1992 in natural history museums in London, Amsterdam, and Leiden. In total Lopau & Adena (2002) mention specimens/records from 16 localities in the North of the island; none of these were artificial water bodies.

Cottle (2006, 2007) published the first records for two new species. However, there was no published systematic survey after that of Lopau & Adena (2002) in 1994 until De Knijf & Demolder (2013). The latter authors made observations at 27 localities across the island in early–mid April 2012, the first published survey to include the North of the island. Tamm (2014) visited 12 localities in the South in early–mid May 2013. The visit of De Knijf & Demolder led to the establishment of the Cyprus Dragonfly Study Group, a team of mainly resident observers which over six years has amassed 22,500 records (by December 2018). A paper decribing the group's studies is due for submission in 2019 (D. Sparrow pers. comm.); their earlier results were included in Sparrow et al. (2016).

Our observations: during 1998–2004, my wife Karen and I lived near Kyrenia in the North of Cyprus; our main interests were the study of birds and to a lesser extent butterflies and natural history generally. In mid 2003 we were asked by Robert Frost † to take note of dragonflies while we were out birdwatching at wetlands and water bodies, which we usually visited at least weekly throughout the year. We had always found dragonflies attractive and were aware of the two suborders which occur on Cyprus but had no previous specialist knowledge of them. Once

we started to observe and record them we became captivated by their beauty, their variety and the unpredictability of their occurrence and became deeply absorbed in their study.

We were fortunate that our observations coincided with three unusually wet hydrometeorological years (October–September) between two long periods of drought. The mean annual rainfall 2001/2, 2002/3 and 2003/4 was 113% of normal; thus in 2003 and 2004 lakes and dam reservoirs were reasonably full and some small temporary streamlets were flowing. The twelve years prior to this included nine with below average rainfall (mean 78% of normal) and by 2000 many waterbodies, including the two largest reservoirs in the North (Kanli/Kanlıköy and Kioneli/Gönyeli) were dry (pers. obs). The four years following our observations also had below average rainfall (mean 76% of normal) and included a year of severe drought, only 54% of normal and the second driest year since records began in 1901 (Department of Meteorology 2018a),

Lopau & Adena (2002) believed there were gaps in the knowledge of the Cypriot dragonfly fauna, with a need above all for the North of the island to be more thoroughly explored; our observations should help to close this gap. As far as we are aware these are also the first regular long-term observations made by residents on the island (as opposed to those that are short-term made by visitors). They were made during a period of rapid environmental change, when there were otherwise very few observations on the island, so provide a chronological link between Lopau & Adena (2002) and the comprehensive and ongoing studies since 2013 of the Cyprus Dragonfly Study Group (http://paphos3rdage.org/dragonfly-study-group; De Knijf et al. 2016; Sparrow et al. 2016; Sparrow & Sparrow 2018; D. Sparrow pers. comm.).

The collation, analysis, and submission of our results was long delayed, though after I learnt of the existence of the Cyprus Dragonfly Study Group I sent them a list of our observations; this contributed to the phenological data in Sparrow et al. (2016). The delay in publication has enabled me to more fully appreciate the significance of our results in relation to the rapid environmental changes on the island.

Methods

Our observations were made from June 2003 to September 2004 and throughout northern Cyprus (Fig. 1 and List of Localities). Recording localities were mainly the reservoirs of the many small dams built in recent decades (Water Development Department 2009) and the few seasonal natural wetlands. Although the Kyrenia Mountains lack perennial streams, on their lower slopes are a few small springs/streamlets which produced records. There are two larger, more perennial springs/streams at Kythrea/Değirmenlik and Lapithos/Lapta but our visits to them did not produce any records. Small, open water tanks surrounded by low flat-topped concrete walls did produce interesting records.

Identification was a steep learning curve, but the techniques of diagnostic points familiar from bird and butterfly identification proved helpful. As a guide to identification we initially had only D'Aguilar et al. (1986) which was useful for easily identified species, but less so for those where confusion might arise. We later obtained Brooks & Lewington (2002) and Askew (2004) which were more useful. Web photos and identification guides were also accessed: Wasscher & Goudsmits (2004) was particularly helpful. Observations were made with binoculars and by photography (Nikon 4500, digital, macro); unfamiliar species were identified later from the photos (no individuals were collected or harmed). For the identification of more difficult or unfamiliar species, Robert and Darren Frost, Graham Giles, and especially Steve Covey and Wolfgang Lopau † gave their opinions of photos e-mailed to them. As a guide to what we might expect to see, we had initially only the checklist in Georghiou (1977), but later Graham Giles sent a copy of his own

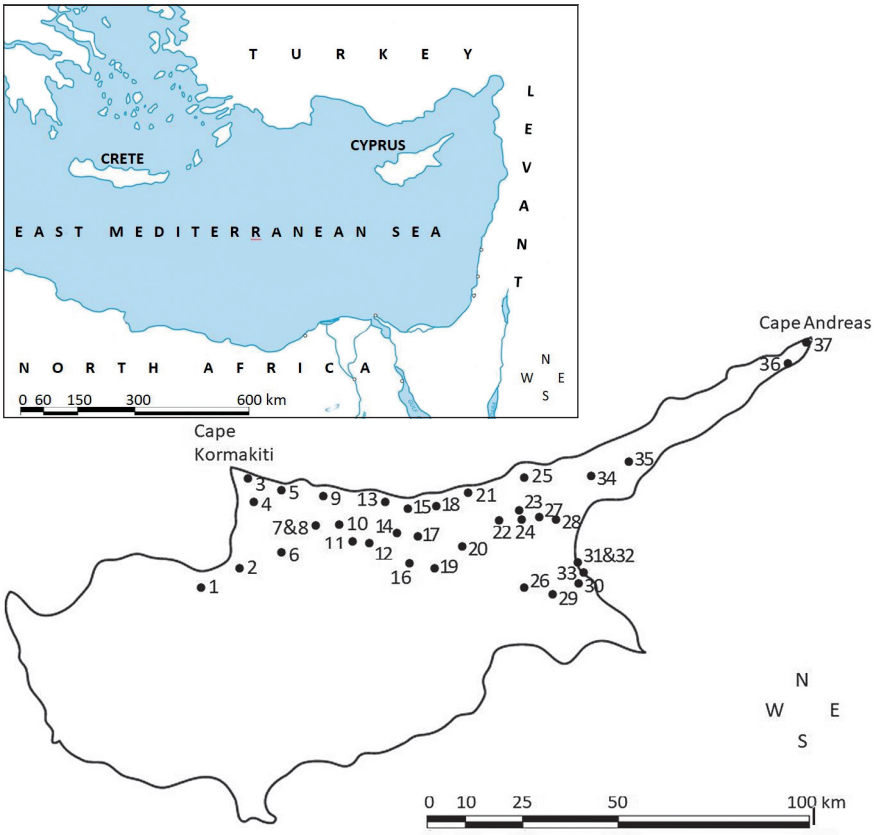


Figure 1. Maps of the East Mediterranean, and of Cyprus with localities. – **Abbildung 1:** Karten des Östlichen Mittelmeers und Zypern mit Darstellung der Fundorte.

recent checklist based on his own observations and those of three residents (compiled 1999, unpublished), and finally we obtained Lopau & Adena (2002). Initially we made few records, but as our experience and knowledge grew and we obtained better identification literature and established a network of experienced contacts, so the number of species we recorded increased, especially so in 2004.

List of Localities

Localities from which records were made (numbered from west to east (Fig. 1), their co-ordinates (WGS84 datum) and the dates of observations at each. Where two places names are given they are Anglicised Greek/Turkish. Alternative names are in brackets.

Loc 1. Lefke/Lefka dam: 35°03'00"N, 32°47'15"E. The water of the reservoir was heavily polluted from former copper mining: 12.07.2004.
Loc 2. Reed beds at 35°09'02"N, 32°51'34"E: 12.07.2004.
Loc 3. Livera/Sadrazamköy water tank: 35°23'17"N, 32°56'54"E. By the right hand side of the road leading from the village to Cape Kormakitis/Koruçam: (a) 27.06.2003; (b) 13.08.2003; (c) 21.03.2004; (d) 17.04.2004; (e) 30.04.2004; (f) 28.07.2004; (g) 16.08.2004.
Loc 4. Kormakitis/Koruçam dam with inflowing streamlet: 35°19'23"N, 32°59'42"E: (a) 28.07.2004; (b) 16.08.2004.
Loc 5. Panagra/Geçitköy dam: 35°19'45"N, 33°04'15"E: 07.07.2003.
Loc 6. Masari/Şahinler dam: 35°10'30"N, 33°05'27"E. Track west of the village on the north side of the main road, a large deep hole in the river bed: 12.07.2004.
Loc 7. Agios Ermolaos/Şirinevler dam: 35°15'46"N, 33°10'02"E: (a) 10.07.2004; (b) 11.08.2004.
Loc 8. Agios Ermolaos/Şirinevler streamlet: 35°16'24"N, 33°10'10"E. Between the village and its dam, a flowing streamlet 2–3 m wide on the West of the road with reeds and eucalyptus: (a) 10.07.2004; (b) 11.08.2004.
Loc 9. Kephalovryso/Başpinar water tank: 35°19'31"N, 33°11'05"E. In the hills above Lapithos/Lapta: 06.07.2004.
Loc 10. Fotta/Dağyolu dam: 35°16'25"N, 33°12'08"E: (a)13.01.2004; (b) 25.05.2004; (c) 26.05.2004; (d) 14.06.2004; (e) 17.07.2004; (f) 14.09.2004; (g) 22.09.2004.
Loc 11. Kanli/Kanlıköy dam: 35°14'17"N, 33°15'43"E: (a) 07.06.2003; (b) 11.07.2003; (c) 27.07.2003; (d) 08.04.2004; (e) 27.05.2004; (f) 14.07.2004; (g) 16.08.2004; (h) 21.09.2004.
Loc 12. Kioneli/Gönyeli dam: 35°14'01"N, 33°18'08"E: (a) 26.12.2003; (b) 03.02.2004; (c) 20.03.2004; (d) 01.06.2004.
Loc 13. Kazaphani/Ozanköy: 35°18'58"N, 33°21'27"E. A village 4 km east of Kyrenia; a garden with wildlife ponds and a concrete water tank: (a) 18.01.2004; (b) 06.02.2004; (c) 01.05.2004; (d) 06.08.2004.

Loc 14. Small dam now often dry (formerly known as Taşkent 1 reservoir) at 35°13’48”N, 33°24’35”E. On the east of the road from Sichari/Kaynakköy to Mia Milia/Haspolat: (a) 11.12.2003; (b) 12.12.2003; (c) 07.02.2004; (d) 24.03.2004; (e) 30.03.2004; (f) 14.05.2004; (g) 05.07.2004.

Loc 15. Klepini/Arapköy dam: 35°19’32”N, 33°25’55”E. The first dam in the foothills east of Kyrenia, accessed from the coast road: (a) 18.06.2003; (b) 09.02.2004.

Loc 16. Mia Milia/Haspolat: 35°11’16”N, 33°26’31”E. The water treatment works for Nicosia: (a) 09.09.2003; (b) 09.04.2004.

Loc 17. Kythrea/Değirmenlik dam: 35°14’53”N, 33°27’30”E. On the west of the old main road from Kyrenia to Nicosia: 25.05.2004.

Loc 18. Alakati/Alagadi dam (Çiftdere reservoir): 35°18’54”N, 33°29’52”E: (a) 18.08.2004; (b) 22.08.2004.

Loc 19. Pediaios river: 35°10’51”N, 33°30’09”E**.** North of the civil airport where the airport road crosses a small river with reeds. The river is seasonal but this section may have some water all year due to the outflow from the water treatment works: 30.07.2004.

Loc 20. Kiados/Serdarlı dam: 35°15’02”N, 33°34’43”E: (a) 05.06.2003; (b) 16.07.2004.

Loc 21. Agios Amvrosios/Esentepe streamlet: 35°20’48”N, 33°34’18”E. A flowing streamlet 1–2 m wide: between the village and the coast: 24.08.2004.

Loc 22. Knodara/Gönendere dam: 35°17’23”N, 33°39’23”E. (a) 20.06.2003; (b) 25.06.2003; (c) 05.07.2004.

Loc 23. Streambed pool at 35°18’52”N, 33°43’47”E. North of Lefkoniko/Geçitkale dam: 16.07.2004.

Loc 24. Lefkoniko/Geçitkale (Egridere) dam: 35°17’23”N, 33°39’23”E: 16.07.2004.

Loc 25. Akanthou/Tatlısu: 35°23’37”N, 33°45’12”E. North coast road, by the village, a non-wetland locality: (a) 02.04.2004; (b) 05.04.2004.

Loc 26. Kouklia/Köprülü dam: 35°07’23”N, 33°45’51”E. A long, low dam with a large shallow reservoir on the Mesaoria, usually dry in summer and in some years disused. Pools below the dam wall may hold water after the reservoir is dry: (a) 05.07.2003; (b) 02.02.2004; (c) 23.03.2004; (d) 10.04.2004; (e) 04.05.2004; (f) 19.05.2004.

Loc 27. Gypsos/Akova dam. 35°16’54”N, 33°47’49”E: (a) 11.06.2003; (b) 16.06.2003; (c) 19.01.2004; (d) 07.02.2004; (e) 11.04.2004; (f) 05.07.2004; (g) 27.07.2004; (h) 18.08.2004.

Loc 28. Syngrasis/Sınırüstü dam: 35°16’57”N, 33°51’02”E. A low dam with a shallow reservoir on the Mesaoria; usually dry in summer: 16.01.2004.

Loc 29. Acheritou/Güvercinlik: 35°05’50”N, 33°50’50”E. A pool with marginal rushes in a roadside ditch ca 1 km west of this village: 19.05.2004.

Loc 30. Famagusta Fresh Water Lake: 35°07’21”N, 33°54’45”E. A large shallow semi-natural wetland complex, despite its name brackish in parts and sometimes dry in summer/autumn in drought years: (a) 24.01.2004; (b) 28.01.2004;

(c) 02.02.2004; (d) 19.02.2004; (e) 19.03.2004; (f) 28.05.2004; (g) 13.07.2004; (h) 24.07.2004; (i) 04.08.2004.

Loc 31. Salamis: 35°11'05"N, 33°54'09"E. A partly wooded, historical, non-wetland locality on the coast immediately north of Glapsides: 27.08.2004.

Loc 32. Glapsides: 35°09'38"N, 33°54'38"E. A natural, seasonal, shallow, brackish wetland on the coast north of Silver Plaj: 28.05.2004.

Loc 33. Silver Plaj: 35°10'03"N, 33°54'19"E. A natural, seasonal, brackish wetland on the coast between Salamis and Famagusta: 28.05.2004.

Loc 34. Ovgoros/Ergazi dam: 35°22'19"N, 33°56'40"E: 09.08.2003.

Loc 35. Galateia/Mehmetçik lake: 35°24'55"N, 34°03'35"E. A shallow, seasonal, fresh water lake on the Karpas Peninsula, always dry in summer: (a) 21.02.2004; (b) 24.03.2004.

Loc 36. Golden Sands streamlet and pool: 35°38'32"N, 34°32'12"E. On the south side of the road east of the Blue Sea hotel and near Golden Sands on the Karpas Peninsula: (a) 02.07.2004; (b) 09.08.2004; (c) 10.08.2004.

Loc 37. Cape Andreas/Zafer: 35°41'40"N, 34°35'15"E. The extreme north-easterly point of the island; a non-wetland locality: (a) 01.04.2004; (b) 27.04.2004.

Systematic List

Locality numbers and letters see List of Localities (above) for descriptions of the localities and the dates of observations at each.

1. *Lestes macrostigma* (Eversmann, 1836)

Recorded from seven localities: two dams, two brackish coastal wetlands, a freshwater wetland, a pool/ditch and on migration/dispersal. Numerous at one dam, a pool/ditch, a brackish coastal wetland (with breeding at the last), and on migration. Eight records late April–May 2004. In detail: **Loc 11e** one; **Loc 26ef** common; **Loc 29** ca 100 mainly on marginal rushes; **Loc 30f** several; **Loc 32** one; **Loc 33** ca 20 mating pairs; **Loc 37b** 100+ all on low bushes in a small area immediately behind the tip of the cape and only a few metres from the cliff top and the sea (Fig. 2).

2. *Sympecma fusca* (Vander Linden, 1820)

Recorded from four localities: three dams and a natural freshwater wetland; it was numerous and breeding at two dams. Six records: early February, late March, and late May 2004. In detail: **Loc 12b** one; **Loc 14c** many mating pairs and ovipositing♀♀; **Loc 14e** one; **Loc 27d** fairly common including several mating pairs; **Loc 30c** one; **Loc 30f** one.

3. *Erythromma lindenii* (Selys, 1840)

Recorded at two dams; at one of them numerous and mating. Seven records: late May, mid-July, and mid-late September 2004. In detail: **Loc 10bc** ten and several

mating pairs; **Loc 10e** six; **Loc 10f** several; **Loc 10g** fairly common and mating pairs; **Loc 11e** four; **Loc 11h** several.

4. *Erythromma viridulum* (Charpentier, 1840)

Recorded from two dams. Five records: late May, mid-June, and late September 2004 at one dam where numerous and breeding and late September 2004 at a second dam. In detail: **Loc 10b** one ♂ on vegetation at the water's edge (KF, Fig. 3); **Loc 10c** 19 ♂♂, 18 of them on the lee side of *Tamarix* at the water's edge; **Loc 10d** 61 ♂♂ and a mating pair (KF) sheltering on the lee side of vegetation, mainly low shrubs, in the strong wind; **Loc 10g** two ♂♂ on emergent vegetation (KF); **Loc 11h** one ♂ on emergent vegetation (KF).

5. *Ischnura elegans* (Vander Linden, 1820)

Recorded from 22 localities: 13 dams, three streamlets, a water treatment works, a garden pond, a pool/ditch, a brackish coastal wetland, a natural freshwater wetland, and an area of reeds. Numerous at eight dams (mating observed at two) and at a freshwater wetland. One instance of cannibalism was observed. 32 records: mid June 2003 and mid March–late September 2004. In detail: **Loc 1** four; **Loc 2** several; **Loc 4a** several; **Loc 7a** several; **Loc 8a** one; **Loc 10c** very common; **Loc 10e** common and mating; **Loc 10f** several; **Loc 10g** several, including one

Figure 2. Cape Andreas, a migrant *Lestes macrostigma* resting on vegetation, 27-iv-2004. – **Abbildung 2.** Cap Andreas, ein in der Vegetation ruhender Migrant von *Lestes macrostigma*, 27.04.2004. Photo: PF

eating another of the same species; **Loc 11e** fairly common; **Loc 11f** 30; **Loc 12c** three; **Loc 12d** fairly common; **Loc 13c** (pond) one; **Loc 14d** several; **Loc 14e** common; **Loc 16b** several; **Loc 17** ten and mating pairs; **Loc 20b** tens; **Loc 21** several; **Loc 22a** several; **Loc 24** two; **Loc 26d** fairly common; **Loc 27b** common; **Loc 27e** several; **Loc 27f** common; **Loc 27g** very common; **Loc 27h** several; **Loc 29** several; **Loc 30f** fairly common; **Loc 32** eight; **Loc 36a** one.

6. *Anax ephippiger* (Burmeister, 1839)

Only migrants recorded; at two non-wetland localities in the Northeast early April 2004. In detail: **Loc 25a** three; **Loc 25b** one; **Loc 37a** at the extreme tip of Cape Andreas, a constant stream of many 1,000s migrating northeast out to sea, many so close to us that we could hear the whirring of their wings as they passed. We arrived at the cape at 12:00 hours and they were then passing close by us at ca 1/second, with others more distant detected with binoculars. There were fewer passing when we left the tip of the cape at 13:30 h.

7. *Anax parthenope* (Selys, 1839)

Recorded from 16 localities: 13 dams, two natural wetlands, and a water treatment works. Numerous at nine dams and mating/ovipositing observed at seven. 35 records: June–July 2003 and mid–late January to late September 2004. In detail: **Loc 1** several; **Loc 4ab** several; **Loc 10b** several; **Loc 10f** several; **Loc 10g** several; **Loc 11a** several; **Loc 11b** one; **Loc 11d** fairly common and mating pairs; **Loc 11e** one; **Loc 11h** fairly common; **Loc 12d** fairly common; **Loc 14c** tandem pair ovipositing; **Loc 14d** several; **Loc 14f** fairly common; **Loc 15a** two; **Loc 16a** common; **Loc 17** fairly common; **Loc 18a** ten; **Loc 20a** very common; **Loc 20b**

Figure 3. Fotta/Dağyolu dam, an *Erythromma viridulum* ♂ perching on vegetation at the water's edge, 25-v-2004. – **Abbildung 3:** Fotta/Dağyolu Stausee, ein *Erythromma viridulum* ♂ am Ufer, 25.05.2004. Photo: KF

one; **Loc 22a** mating pairs; **Loc 26a** three; **Loc 26b** > 10 hunting; **Loc 26c** fairly common and mating pairs; **Loc 26d** fairly common; **Loc 27a** only a few before sunset but scores after, when many caught and eaten in flight by two Hobbies *Falco subbuteo* which breed in the nearby Kyrenia mountain range, we several times heard the impact as the fast-flying falcons struck the dragonflies; **Loc 27c** one; **Loc 27e** many tandem pairs ovipositing; **Loc 27g** tens; **Loc 30b** four hunting; **Loc 30e** several and a mating pair; **Loc 30f** several; **Loc 35a** three; **Loc 35b** fairly common and mating pairs.

8. *Crocothemis erythraea* (Brullé, 1832)

Recorded from 25 localities: 14 dams, three streamlets, two areas of reeds, a garden pond, a pool/ditch, a water tank, a water treatment works, a natural wetland, and a non-wetland locality. Numerous at ten dams, a water tank, and a streamlet, with ovipositing at a garden pond. 35 records: early July, early–mid August and early September 2003, and late April, May, early June, July–August, and mid–late September 2004. In detail: **Loc 1** ten; **Loc 2** several; **Loc 3b** fairly common; **Loc 3e** eight; **Loc 3f** 15; **Loc 3g** common; **Loc 4ab** fairly common; **Loc 7a** several; **Loc 8a** 12; **Loc 10c** fairly common; **Loc 10f** five; **Loc 10g** several; **Loc 11f** 20; **Loc 12d** one; **Loc 13c** (pond) several ovipositing; **Loc 14f** common; **Loc 16a** several; **Loc 17** fairly common; **Loc 18b** ten; **Loc 19** several; **Loc 20b** tens; **Loc 21** present; **Loc 24** two; **Loc 26a** common; **Loc 26d** fairly common; **Loc 27e** several; **Loc 27g** common; **Loc 27h** common; **Loc 29** several; **Loc 30i** 20; **Loc 31** one; **Loc 34** several; **Loc 36a** one; **Loc 36b** eight.

9. *Diplacodes lefebvrii* (Rambur, 1842)

Recorded from five localities: three dams, a natural wetland, and a streamlet/pool. Peak numbers early–mid August when 100s at two localities. 12 records: late May, July, early–mid August, and late September 2004. In detail: **Loc 4a** several; **Loc 4b** fairly common; **Loc 10g** several; **Loc 27f** one; **Loc 27g** ca 30; **Loc 27h** 100s, nearly all adult ♂♂; **Loc 30f** 20; **Loc 30g** common/very common; **Loc 30h** common/very common; **Loc 30i** 100s, by far the most numerous dragonfly at that locality on that date. **Loc 36b** five including one ovipositing; **Loc 36c** ten ♂♂, two ♀♀.

10. *Orthetrum brunneum* (Fonscolombe, 1837)

Recorded from six localities: three streamlets, two dams, and a pool/ditch. Present only in small numbers. Seven records: late July 2003 and mid–late May, mid-June, and August 2004. In detail: **Loc 8b** several; **Loc 10d** one; **Loc 11c** one; **Loc 11e** one; **Loc 21** present; **Loc 29** one; **Loc 36b** three.

11. *Orthetrum cancellatum* (Linnaeus, 1758)

Recorded from four localities: three dams and a water tank. Present only in small numbers. Six records: late July and mid-August 2003, and mid–late May and

mid-June 2004. In detail: **Loc 3b** three; **Loc 10c** two; **Loc 10d** one; **Loc 11c** one; **Loc 11e** seven; **Loc 14g** six.

12. *Orthetrum chrysostigma* (Burmeister, 1839)

Recorded from eight localities: three dams, two streamlets, two water tanks, and a pool. Numerous at a streamlet and a water tank. 12 records: late March, mid–late April, July, and mid-August 2004. In detail: **Loc 3c** one; **Loc3d** ten; **Loc 3e** one; **Loc 3f** eight; **Loc 3g** three; **Loc 4b** one; **Loc 8a** 60+; **Loc 9** several; **Loc 11f** two; **Loc 14e** one; **Loc 23** one; **Loc 36a** one.

13. *Orthetrum coerulescens* (Fabricius, 1798)

Recorded from six localities: three streamlets, a water tank, a dam, and an area of reeds. Numerous at a streamlet. Seven records: July and mid–late August 2004. In detail: **Loc 2** several; **Loc 4a** several at inflowing streamlet; **Loc 7a** present; **Loc 8a** several 20s; **Loc 8b** one; **Loc 9** several; **Loc 21** present.

14. *Orthetrum sabina* (Drury, 1773)

Recorded from 14 localities: 12 dams, a water tank, and a streamlet/pool. Numerous at two dams. 18 records: late June, early and late July and early August 2003, and mid-late May, early June, July-August, and mid September 2004. In detail: **Loc 3a** several; **Loc 4a** four; **Loc 4b** two; **Loc 5** one; **Loc 7a** two; **Loc 10e** four; **Loc 10f** two; **Loc 11c** one; **Loc 11e** four; **Loc 11f** two; **Loc 12d** 12 along ca 200 m of shoreline; **Loc 14f** common; **Loc 17** five; **Loc 18b** one; **Loc 22b** one; **Loc 27g** six; **Loc 34** one; **Loc 36c** one.

15. *Orthetrum taeniolatum* (Schneider, 1845)

Only one record, from a streambed pool. **Loc 23** one ♂.

16. *Selysiothemis nigra* (Vander Linden, 1825)

Recorded from eight dams; numerous at three and breeding at one. Ten records: mid June 2003 and July and mid-late August 2004. In detail: **Loc 1** four; **Loc 4a** 20 including one ovipositing; **Loc 6** one; **Loc 11f** 12; **Loc 11g** six; **Loc 14g** fairly common; **Loc 18b** eight; **Loc 22a** four; **Loc 22c** six; **Loc 27f** one.

17. *Sympetrum fonscolombii* (Selys, 1840)

Recorded from nine localities: six dams and two natural freshwater and one brackish wetland. Numerous April–May; breeding noted at three dams. 13 records: mid–late March, early–mid April, early and late May, early June, and late September 2004. In detail: **Loc 10c** several; **Loc 10g** several mating pairs; **Loc 11d** common with tandem pairs ovipositing; **Loc 11h** several; **Loc 12d** four; **Loc 17** fairly common; **Loc 26de** fairly common; **Loc 27e** common and mating pairs; **Loc 30e** several; **Loc 30f** one; **Loc 32** one; **Loc 35b** five.

18. *Sympetrum meridionale* (Selys, 1841)

Only three records from two dams mid–late September 2004. **Loc 10f** one; **Loc 10g** several; **Loc 11h** several.

19. *Sympetrum striolatum* (Charpentier, 1840)

Recorded at nine localities: seven dams, a natural wetland, and a garden pond. Numerous at seven localities and breeding at at least five. 18 records: mid–late December 2003, mid–late January, early–mid February, early March, mid-August, and mid-September 2004; there was a notable gap in the records early March to mid-August 2004. In detail: **Loc 7b** common; **Loc 10a** several including a mating pair; **Loc 10f** several; **Loc 12a** ten including several mating pairs, one of them ovipositing; **Loc 12b** two; **Loc 13a** (pond) tandem pair ovipositing; **Loc 13b** two and a mating pair; **Loc 14a** three; **Loc 14b** several; **Loc 14c** several including two mating pairs; **Loc 15b** fairly common; **Loc 27c** ten and a mating pair; **Loc 27d** several; **Loc 28** fairly common; **Loc 30a** several; **Loc 30b** ten; **Loc 30c** fairly common; **Loc 30d** several.

20. *Trithemis annulata* (Palisot de Beauvois, 1807)

Recorded from 16 localities: 13 dams, two streamlets and a river. Numerous at 12 localities with 100s at two of them and ovipositing at one. 22 records: mid July 2003 and late May, early June, July, mid–late August, and mid–late September 2004. In detail: **Loc 1** 20; **Loc 4a** common; **Loc 4b** fairly common; **Loc 6** 100s; **Loc 7a** fairly common; **Loc 8a** one; **Loc 10b** several; **Loc 10f** ten; **Loc 10g** several; **Loc 11b** 100s resting in the shade of eucalyptus trees; **Loc 11f** 100s resting in the shade of eucalyptus and cypress trees; **Loc 11h** fairly common; **Loc 12d** common; **Loc 17** fairly common; **Loc 18b** 30; **Loc 19** several, ovipositing; **Loc 20b** several; **Loc 21** present; **Loc 22c** fairly common; **Loc 24** tens; **Loc 27f** common; **Loc 27g** fairly common.

21. *Trithemis arteriosa* (Burmeister, 1839)

Recorded from two water tanks, early and mid-August 2004. In detail: **Loc 3g** one ♂ resting on the top of the wall of the water tank (Fig. 4); **Loc 13d** one ♂ resting on the top of the wall of the tank all afternoon; gone the next day.

Discussion

Comments on individual species in the Systematic List

Lestes macrostigma

Previously published records are: two in the early literature then 17 museum specimens, the last in 1948 (Lopau & Adena 2002), 2007 (N. Cottle in Sparrow et al. 2016), a breeding population of 1,000 adults, 100 tenerals, and 20♀♀ ovipos-

iting at Paralimni Lake (Sotira) in the Southeast in 2012 (De Knijf & Demolder 2013), thousands there 2013 but many fewer 2014–16, and small populations at several other localities since 2014 (Sparrow et al. 2016). Nearly all of these records are from typical breeding habitats for the species, i.e., brackish seasonal coastal and inland wetlands in lowland areas (Boudot & Rabb 2015).

Our records from 2004 also mainly follow this pattern. Soils in low-lying inland areas of the southeast often have raised salinity (Fink 1967; Hadjiparaskevas 2005) so the localities at Acheritou/Güvercinlik and Kouklia may provide suitable breeding habitat. At the time I was unaware that this species oviposits into rush stems (Matushkina & Lambret 2011), so I may have overlooked ovipositing at Acheritou/Güvercinlik. That site, and those at Famagusta, Glapsides, and Silver Plaj are all only 13–15 km from Paralimni/Sotira, and Kouklia is only 21 km from there, so this southeastern area appears to hold the main breeding populations of this species on Cyprus. It apparently provides ideal breeding habitat, not only in its salinity but (as elsewhere on the Mesaoria) also in its aridity: its AET/PET ratio (actual/potential evapotranspiration) being 0.19–0.20 in normal rainfall years (Flint 2011), indicating the high evaporation necessary to create the temporary breeding habitat required by this species.

Figure 4. Livera/Sadrazamköy water tank, a *Trithemis arteriosa* ♂ on the top of the wall of the water tank, 16-viii-2004. – **Abbildung 4:** Livera/Sadrazamköy Wasserbehäter, *Trithemis arteriosa* ♂, 16.08.2004. Photo: PF

Lestes macrostigma undergoes strong annual fluctuations in numbers (Boudot & Rabb 2015); clearly this is also so on Cyprus where years with high numbers (2004, 2012, 2013) followed winters with higher than average rainfall, and two of the three years (2014, 2016) with low numbers followed severe drought winters (Department of Meteorology 2018a). Lopau & Adena (2002) failed to find this species in 1994 after a low rainfall winter. Adequate winter rainfall thus presumably provides favourable water levels at its breeding localities. Fifteen of the museum specimens have dates: 1931 (4 specimens), 1938 (4), 1939 (2) and 1948 (5) (Lopau & Adena 2002); all these years also followed high rainfall winters (Department of Meteorology 2018a). Such winters were more frequent prior to 1970, and drought winters less so; thus *L. macrostigma* was perhaps more numerous in the past than it now is. On Cyprus this species breeds in spring (Sparrow et al. 2016); the absence of records between 1948 and 2004 being probably due to a scarcity of observations at that season, especially in the southeast.

The record from Cape Andreas on 27 April 2004 clearly differ in circumstances from all the other above records. The cape is the prime locality on the island for bird migration – migrant birds are funnelled to the tip of the cape by the topography of the Karpas Peninsula (Flint & Stewart 1983, 1992); this can apparently also happen with migrating dragonflies (see *A. ephippiger* below). At the time of our observations the nearest breeding localities known to us were ca 83 km distant to the South-Southwest at Glapsides and Silver Plaj; no closer breeding localities are currently known to the The Cyprus Dragonfly Study Group either who also do not know of any suitable breeding pools for this species on the peninsula or at the cape (D. Sparrow pers. comm.). Thus these individuals at the cape appear not to have originated there but to have been dispersers/migrants. In view of the concentrated nature of this occurrence and the species' limited distribution in the east Mediterranean region (Boudot & Rabb 2015) these individuals most probably originated from a breeding locality elsewhere on the island. This is the first record of the species' apparent migration/dispersal on Cyprus. Isolated records from elsewhere suggest that it may wander widely but low numbers inhibit detection (Dijkstra & Lewington 2006); the high number of dispersers/migrants at Cape Andreas thus appears to be unusual for the species.

Sympecma fusca

There were no mid-winter records in Lopau & Adena (2002) but the numbers and activity we witnessed in early February 2004 suggested that the species might be encountered in mid winter also and it now has been (Sparrow et al. 2016).

Erythromma lindenii

Not listed by Georghiou (1977) or Giles (unpubl.). The only sightings earlier than ours appear to be from June 1994, when the species was found at four dams (numerous at two of them) in the South of the island (Lopau & Adena 2002). Standing waters where this species occurs are usually influenced by wind, which

generates waves which help to oxygenate the water and breakdown stratification, reproducing conditions found in its prefered gently running water habitats (Kalkman & Dyatlova 2015). In this context it may be significant that Fotta/Dağyolu dam is often extremely windy on summer days (pers. obs. and see the next species, D. Sparrow pers. comm.), probably due to local topography and the daily heating of the land surface of the interior of the island by insolation (Department of Meteorology 2018b). The species was found again in 2012, in a stream (De Knijf & Demolder 2013) but more recently has been found at quite sheltered standing waters on the island, which however have open water which may ensure good oxygenation (D. Sparrow pers. comm.). Although not common it is now frequent at many of the larger dams and ponds (Sparrow et al. 2016). The now regular observer coverage may be a factor in this apparent recent increase, as may be the recent construction of more of these artificial water bodies and/or because the higher year-round air temperatures will have increased the rate of oxygen solution from the atmosphere into surface water (Downing & Truesdale 1955), improving habitat quality.

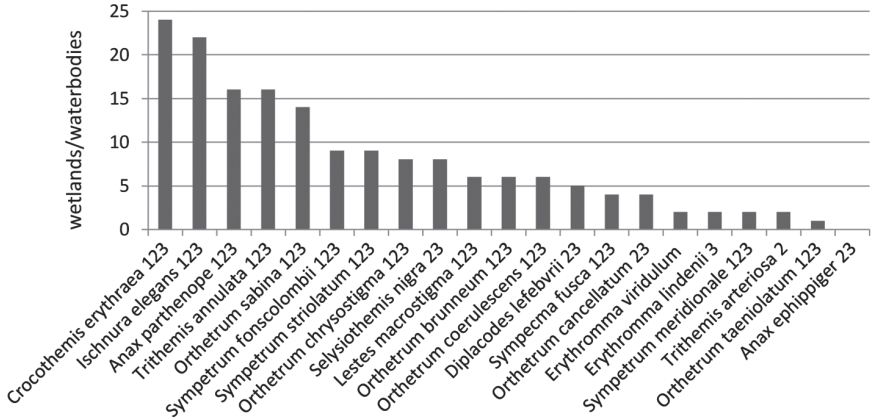
Erythromma viridulum

Our records are the first of this species from Cyprus. During our visits to Fotta/Dağyolu in May and June 2004, no ♂♂ were seen on emergent vegetation (as might have been expected; Askew 2004) and some were on low shrubs 10–20 m distant from the reservoir, on its downwind side; this may have been because the emergent vegetation was too exposed in the strong wind. The pattern of records, late May and mid-June, none mid-July, then late September suggests that there may have been two generations at this reservoir, as is the case in Greece (Askew 2004). We were fortunate to find the breeding population when we did; Fotta/Dağyolu reservoir is small and shallow and almost certainly would have been dry during the preceding drought (as were the larger and deeper Kanli/Kanlıköy and Kioneli/Gönyeli) and in the following drought. This breeding population there thus seems likely to have been impermanent. The two dams at which this species was recorded by us are only 5 km apart. The species was rediscovered on the island in May 2012 at Kioneli/Gönyeli (only 4 km from Kanli/Kanlıköy) and subsequently at seven other localities (D. Sparrow pers. comm.) though it remains relatively uncommon (Sparrow et al. 2016). This is an unmistakable species, unlikely to pass unnoticed, but of its six named localities (Sparrow et al. 2016; this study), none are mentioned by Lopau & Adena (2002) so it may have been present but unrecorded prior to 2004.

Ischnura elegans

The most widely distributed and most frequently encountered damselfly (Zygoptera) recorded by us (Table 1); this status agrees with those in Lopau & Adena (2002) and in Sparrow et al. (2016). The congeneric *I. intermedia* was discovered in the Southwest of Cyprus in 2013 (De Knijf et al. 2016) and is now known to occur more widely in river valleys there (Sparrow et al. 2016). At the time

Table 1. Frequency of records of Odonata in northern Cyprus 2003–2004. The total number of wetlands/waterbodies at which each species was recorded. Non-wetland/waterbody localities are not included. Numbers after the species' names indicate the checklists in which each species was included at the time of our observations: **1** Georghiou (1977), **2** Giles (unpublished) and **3** Lopau & Adena (2002). All the species we recorded are included in the current checklists: Boudot & Kalkman (2015) and Sparrow et al. (2016). – **Tabelle 1:** Häufigkeit der Libellenfunde auf Nordzypern 2003–2004. Angegeben ist die Anzahl der Gewässer/Feuchtgebiete pro Art. Funde abseits von Gewässern gehen nicht in die Darstellung ein. Die Ziffern markieren vorherige Erfassungen: **1** Georghiou (1977), **2** Giles (unveröffentlicht) und **3** Lopau & Adena (2002). Alle Arten sind in den aktuellen Checklisten von Boudot & Kalkman (2015) und Sparrow et al. (2016) enthalten.



of our observations this species was not in the field guides (it is still not) and I was unaware of its existence. Its breeding habitat (De Knijf et al. 2016; Sparrow et al. 2016) is apparently absent from the North though dispersers could occur anywhere. Males of both species have a blue taillight on S8, but *I. intermedia* differs by having it variably on S9 also (Sparrow et al. 2016). Had I noticed such an individual I hope I would have photographed it and sent if for expert opinion, as I did with other unfamiliar species. Our three photos labelled *I. elegans* show the taillight on S8 only.

Anax ephippiger

We had visited Cape Andreas many times since 1969 to study bird migration but 1 April 2004 is the first time we had ever witnessed a mass migration of dragonflies there. We had similarly also often visited Cape Kormakitis/Koruçam on the northwest coast but although we had often seen northward butterfly migration there in spring (e.g., Flint 2003) we had never seen dragonfly migration there either. The distribution and movements of this species (e.g., Dumont & Desmet 1990; Parr 2011; Kalkman & Monnerat 2015a) suggest that the origin of the migrants was Africa. *Anax ephippiger* is a known migrant to Cyprus early Febru-

ary to late May (Sparrow et al. 2016) but this is the first record from the North of the island and the first of visible migration. The high rate at which individuals were passing appears to be exceptional when compared with previous records from the Mediterranean region (Kalkman & Monnerat 2015a), probably because the stream of migrants was so concentrated by the local topography (see *L. macrostigma* above). The few individuals we saw later at Akanthou/Tatlısu on the north coast were presumably stragglers from the mass migration at Cape Andreas. North-eastward migration of 100s was seen again at the cape on 2 March 2012 and 2 April 2014 (M. Haacks in Sparrow et al. 2016).

The Klidhes islands, which extend for 2.7 km to the Northeast of Cape Andreas, apparently act as a "leading line" (Geyr von Schweppenburg 1963) for migrant birds, both in spring and autumn, keeping them heading northeast as they leave the cape (Flint & Stewart 1983, 1992). If that is also so for migrating dragonflies then the intended direction of these migrant streams once over the open sea may not have been northeast, but perhaps more northerly.

Anax parthenope

Lopau & Adena (2002) list this species from 17 localities, mostly reservoirs and other still waters; our observations add a further 16 localities to that total, 14 of them artificial water bodies. It now typically breeds at permanent larger ponds and reservoirs (Sparrow et al. 2016). Its status across these three time periods suggests that this lentic species has greatly benefitted from the recent creation of such artificial habitats. The January 2004 records from Gypsos/Akova and Famagusta were at the time the earliest for the east Mediterranean if not the whole Mediterranean (W. Lopau pers. comm.) and are still the earliest for Cyprus (D. Sparrow pers. comm.). That we were out weekly birdwatching at water bodies and wetlands throughout the winter (when there are many interesting birds) enabled us to detect these unusually early dragonfly occurrences. Anyone looking only for dragonflies at that time of year would probably not have productive excursions. It isn't clear if such early records are a reflection of the recent milder winters or have simply been overlooked in the past through a lack of observation during these months.

The record of many caught and eaten by Hobbies *Falco subbuteo* at Gypsos/Akova reservoir on 11 June 2003 may be significant. Large flying insects, especially dragonflies, are the main food of Hobbies (Orta et al. 2018). The breeding population of this falcon has recently increased on Cyprus, partly perhaps in response to an increase in dragonfly biomass following the construction of many artificial waterbodies (Flint 2019). *Anax parthenope*, the most numerous and widespread large dragonfly on Cyprus and closely associated with artificial water bodies, may thus be important in the increase of this falcon on Cyprus.

Crocothemis erythraea

The most widely distributed dragonfly on the island (Lopau & Adena 2002); our observations support this (Table 1).

Diplacodes lefebvrii

Not recorded from Cyprus until 1983; it had previously been found at only three localities in the south of the island, in unspecified/small numbers: 1–3 individuals (Lopau & Adena 2002). Thus the number of localities and the very high numbers of individuals recorded by us were unexpected. This is an Afrotropical species which is slowly extending its range northward in the Mediterranean region (Kalkman & De Knijf 2015); our records suggest that this range extension is continuing on Cyprus, probably in response to the warming climate there. Large numbers were at two localities in the South of the island 2013 and 2014 but it disappeared from them following subsequent low rainfall years (D. Sparrow pers. comm.).

Orthetrum brunneum

Widespread and present on all running waters in the southwest of the island (Lopau & Adena 2002); it remains common is such habitats (Sparrow et al. 2016). The former authors expected it to be more widespread in the North of the island than their map suggested (only two localities); our records showed that it was, but not greatly so, probably because of the scarcity of flowing waters.

Orthetrum cancellatum

First recorded 1994 and of sparse distribution in the south of the island, suggesting that it is a recent immigrant (Lopau & Adena 2002). Our records, the first from the North of the island, show that at the time of our observations it was of sparse distribution there also. It remains relatively uncommon on the island (Sparrow et al. 2016) and In the South is confined mainly to higher altitudes (D. Sparrow pers. comm.). This is a European species which in Cyprus is near the southern limit of its geographical range (Kalkman & Ambrus 2015); the warming climate of the island may mean that it will remain relatively uncommon and that in the long-term its population may decline.

Orthetrum chrysostigma

An African/Middle Eastern species which has slowly expanded its range northwards into the Iberian Peninsula since the 1980s, though there is no clear evidence of a similar increase in the eastern Mediterranean (Kalkman & Monnerat 2015b). Records from Cyprus prior to our observations are few and scattered across the island: eight localities with a maximum of only six individuals at any locality (Lopau & Adena 2002). Our records doubled that number of localities and involve much higher numbers of individuals. This species is now (in 2018) very common (D. Sparrow pers. comm.). This change in status across these three time periods indicates an apparently large increase of the population of this species on the island, probably in response to the warming climate.

Orthetrum coerulescens

One of the commonest dragonflies on the island, found on many running waters but also at dams with marginal vegetation in the southwest (Lopau & Adena 2002) and it remains common at running waters in the southwest (Sparrow et al. 2016). Our comparatively few records probably reflect the scarcity of suitable habitats in the North of the island.

Orthetrum sabina

In nearly 140 years there were only 12 records, confined to three localities in a small area near the south coast of the island (Lopau & Adena 2002) and those authors in a month's observations in 1994 found it at only one site, Germasogeia. Our records appear to show a remarkable increase in its numbers and distribution by 2003–2004 and this increase has apparently continued: the species is now common at many pools and dams at low altitudes across the island: 66 localities by December 2018 (D. Sparrow pers. comm.). *Orthetrum sabina* is striking in appearance, unmistakable and can not be confused with any other dragonfly on the island (Sparrow et al. 2016) and thus unlikely to have been overlooked in the past. It is a species of the Old World tropics and subtropics (Kalkman 2015); this recent increase on Cyprus is probably a response to the rapid warming of the island's climate. If this species has colonised from the South in response to such warming then it may not be coincidence that its initial localities were near the south coast, where winters are warmer than inland (Department of Meteorology 2018b) and where Germasogeia reservoir, in a sheltered south-facing valley, may possess a favourable micro-climate.

Selysiothemis nigra

Recorded by Lopau & Adena (2002) from only eight dams close together north of Limassol in the south of the island. Our records from 2003–2004 add an additional eight widespread dams and it now occurs at many of the dams and ponds on the island (Sparrow et al. 2016). The species generally is known to be increasing due to the creation of man-made habitats (Kalkman & Bogdanovic 2015); thus it may be that the recent large increase in such habitats on Cyprus is the reason for the apparent increase of this species on the island, plus in the case of our observations the high rainfall years preceding them.

Sympetrum fonscolombii

Our records agree with the common and widespread status given by Lopau & Adena (2002) and Sparrow et al. (2016). This is another lentic species which seems likely to have benefited from the recent very large increase in dams and ponds.

Sympetrum meridionale

Recorded only from the south of the island by Lopau & Adena (2002); those authors do not give an abundance status but their text implies that it is not com-

mon; it is described as rare (only nine records in total) by Sparrow et al. (2016) and our results support this status. Overwintering (postulated by Lopau & Adena 2002 and De Knijf & Demolder 2013) was not observed by us. *S. meridionale* is extending its range northwards in west and central Europe apparently in response to higher summer temperatures there, but on Cyprus it is near the southern limit of its distribution (Kalkman et al. 2015a), thus the island's warming climate may mean that this species will in future remain rare or become more so.

Sympetrum striolatum

Our results support the implied fairly common and widespread status given by Lopau & Adena (2002) and Sparrow et al. (2016). Winter mating and ovipositing appear not to have been recorded prior to our observations but are now know to be regular (Sparrow et al. 2016). The notable gap in our records fits the now known annual phenology of this species on Cyprus (D. Sparrow pers. comm.).

Trithemis annulata

Now one of the commonest dragonflies on the island (Sparrow et al. 2016), Lopau & Adena (2002) presented evidence to suggest that prior to the 1970s it had been rare but subsequently had greatly increased apparently in response to the construction of man-made habitats, though the warming climate may also be a factor (Kalkman et al. 2015b). Surprisingly, prior to our observations there was only one record from the North of the island though we found it to be common and widespread there, probably due to the above reasons and to earlier under-recording. Hundreds resting in the shade of trees in mid July 2003 and July 2004 was presumably normal behaviour though it does not appear to be mentioned in the literature for this species.

Trithemis arteriosa

The individual present only on the afternoon of 6 August 2004 at a daily monitored locality was presumably a transient/migrant. That seen on 16 August 2004 may have been a local breeder or a migrant; the locality is close to Cape Kormakitis, where migrant birds and butterflies often concentrate and rest before departure (pers. obs.). This species in not listed by Georghiou (1977) nor by Lopau & Adena (2002). The only previous records I'm aware of are those of Graham Giles (unpubl. and pers. comm.) who in 1999 located the species at three localities in the South of the island: Saettas river near Platres on 13 June, Germasogeia dam on 19 June, and Perapedi dam on 20 June. GG collected one specimen from each locality which were identified by the late Allen (D.A.L.) Davies in Cambridge, UK (GG still has AD's notes on these specimens). Also it was usual at that time for AD to add GG's specimens to the Cambridge University Zoological Museum collection where they may be. The species was subsequently found in September–October 2006 at five localities in the Southeast of the island (Cottle 2006, 2007), which are the first published records. This African species is extending its range north-

wards in the eastern Mediterranean, to Cyprus, and the southern coast of Turkey (Boudot & Ferreira 2015), perhaps because of the rapidly warming climate in this region. These 1999, 2004, and 2006 records from Cyprus appear to illustrate the early stages of this range extension to the island though there may be earlier records than these: Boudot & Kalkman (2015) mention unpublished possible Cyprus records dating back to 1990. The species is now, in 2018, very common and quite widespread on the island (D. Sparrow pers. comm.), showing a very large increase in numbers and distribution since our observations in 2004.

General discussion

Our observations were made during a period of rapid and continuing warming and drying of the island's climate and after a large increase in the number and capacity of artificial waterbodies. Some of our results appear to reflect these environmental changes, e.g., the records for *D. lefebvrii*, *A. parthenope*, *O. chrysostigma*, *O. sabina*, *S. nigra*, *T. annulata*, and *T. arteriosa*. Other significant records include: *Lestes macrostigma* (early records and migration/dispersal), *S. fusca* (early records), *E. lindenii* (recorded in only one previous year), *E. viridulum* (new species), *A. ephippiger* (mass migration), *S. striolatum* (mid-winter mating pairs and ovipositing), and *T. arteriosa* (no published records prior to our observations). Thirty two of our wetland/waterbody localities were not mentioned by Lopau & Adena (2002) but most did not exist when the earlier observations and collecting in the North occurred. Twenty nine were also not visited by De Knijf & Demolder (2013) though most are now monitored by the Cyprus Dragonfly Study Group (Sparrow et al. 2016, D. Sparrow pers. comm.).

The earlier under-recording appears not to be a major causal factor in the apparent increases in numbers and distribution listed above. The most significant earlier observations were those of Lopau & Adena (2002) in 1994; the former author was a careful, experienced and respected observer (e.g., Burkart et al. 2009) and where he found species rare, uncommon or absent it is likely that this reflected their true status at that time, especially when that status is supported by the earlier literature and the specimen record. The only exception to this being *L. macrostigma* but there were good reasons why this species was not found by Lopau & Adena (2002). It is also noteworthy that those species listed above which have increased are ones which would benefit from the construction of artifical waterbodies and/or are at the northern limit of their distribution and thus would be liable to benefit from the warming of the island's climate. By contrast, *O. cancellatum* and *S. meridionale* which have remained scarce, are both near the southern limit of their distribution. This study also shows increases not only between the previous literature and our observations, but also between our observations and the present day. For these reasons it seems likely that the apparent increases described here are not artefacts produced by earlier under-recording, but represent real changes in status. Dragonflies are highly dispersive, swift to colonise new habitats and to

alter their range margins and abundance in response to climate change (e.g., Hickling et al. 2005; Boudot & Kalkman 2015); such changes in status appear to be happening on Cyprus. The climate of Cyprus is predicted to warm further during this century, and to become more arid (Giannakopoulos et al. 2010), resulting in probable further marked changes in the island's dragonfly fauna.

Of the 33 species listed from Cyprus by Lopau & Adena (2002), 19 had previously been recorded from the North of the island. Of the latter total we recorded twelve, plus nine (spp 3, 4, 6, 9, 11, 14, 16, 18, and 21 above) not previously recorded there, two of which (4 and 21) were not listed by Lopau & Adena (2002). Of the seven species previously recorded from the North of the island that we did not encounter – *Calopteryx splendens*, *Epallage fatime*, *L. viridis*, *L. barbarus*, *Caliaeschna microstigma*, *Onychogomphus forcipatus*, and *T. festiva* – six are lotic and have only 1–3 previous records each from the North. In view of the scarcity of flowing streams in the North these earlier records may have referred to mainly vagrants/wanderers, though such species may have been more frequent in the North in the past when the climate was wetter. I had hoped to find lotic species, particulary *C. splendens*, at the Kythrea/Değirmenlik and Lapithos/Lapta springs/streams but we did not find any dragonflies at either locality. I had also hoped to find *Aeshna mixta* and the spectacular *A. imperator* and always looked for the latter at the reservoirs but never found any examples of either species; both have now been recorded from the north (Sparrow et al. 2016, D. Sparrow pers. comm.).

The whole island species total now stands at 37 (Boudot & Kalkman 2015; Sparrow et al. 2016) though in six years of monitoring by the Cyprus Dragonfly Study Group only 32 have been found (D. Sparrow pers. comm.). The lower number of species recorded from the North compared with these totals probably has several causes: much less previous study compared with the South (Lopau & Adena 2002), fewer lotic species due to a scarcity of habitat, and the species richness/area relationship (e.g., MacArthur & Wilson 1967). The second and third reasons are probably interrelated in that smaller areas tend to have less habitat diversity than larger areas (e.g., Whittaker & Fernández-Palacios 2007).

It has been twice remarked that Cyprus has a much lower dragonfly species richness than Turkey, the nearest continental mainland (Lopau & Adena 2002; De Knijf & Demolder 2013). Similar differences exist with the island's birds (Flint & Stewart 1983, 1992) and butterflies (calculated from Thomson 2010 and John 2018). These differences in species richness between an island and its adjacent mainland would be expected due to island biogeographical factors, rather than to difficulties of dispersal; i.e., the insular conditions often prevent immigrants of potentially colonising species from establishing viable long-term populations (e.g., MacArthur & Wilson 1967; Schoener 2010).

Lopau & Adena (2002) also remarked that the Cypriot dragonfly fauna has a very narrow range of species, with eleven (now ten) genera – all of which have one or more species occurring on the south coast of Turkey – absent from the island. Genera particularly noticeable by their absence are: *Platycnemis*, *Pyrrhosoma*, *Coenagrion*, *Enallagma*, *Ceriagrion*, *Gomphus*, *Cordulegaster*, and *Libellula*. Island

biogeographical factors are probably responsible for these absences; of particular importance in most of these absences may be the island's poor habitat diversity, e.g., there are few permanently gently flowing streams, no permanent bogs or marshes, no permanent natural freshwater or brackish wetlands, and no permanent waterbodies with lush, marginal vegetation, and non-fluctuating water levels. The reservoirs of the many modern dams provide semi-permanent habitat for lentic species though their water levels often fluctuate greatly and many dry out in the now frequent severe drought years (pers. obs.). The aridity and unreliable rainfall of the island appear to be the main reasons for this poor habitat diversity.

Islands are well known to be "hotspots" of biodiversity, rich in endemics (e.g., Whittaker & Fernández-Palacios 2007); Cyprus is no exception, with many endemic plants (Tsintides & Kourtellarides 1998) and animals (Sparrow & John 2016). Looking at those animals which, like dragonflies, have strongly dispersive powers of flight, Cyprus has a high level of avian endemism, in fact the highest in Europe, (Flint & Stewart 1983, 1992; Stattersfield 1998; Gill & Donsker 2018) and a fairly high level of butterfly endemism (John 2018) but strangely it has no endemic dragonfly species. This seems especially surprising when the Mediterranean basin has a relatively high proportion of endemic dragonfly species (23, nearly one in seven species), including eight in the neighbouring Levant and two on Crete (Riservato 2008) which is also in the east Mediterranean basin and of similar size to Cyprus. Many of the Mediterranean endemics are species of flowing water (Riservato et al. 2008); the permanence of such habitats on Cyprus is questionable and may be the main reason for the absence of Cypriot endemics. Cyprus has the lowest precipitation of any large Mediterranean island and is the only one with a semi-arid climate (Koundouri 2007). It is also subject to repeating cycles of severe drought year clusters (Griggs et al. 2014). Historically such prolonged droughts have caused the drying of springs and wells, the death of forest trees, crop failure, famine, and emigration (Christodoulou 1959; Thirgood 1987). Droughts also severely and disproportionately reduce recharge to groundwater on Troodos (Mederer 2009), on which the base flow of the streams there depends (Water Development Department 2002). Such historical extreme climatic events may thus have caused the periodic drying of normally perennial streams as well as all natural wetlands, resulting in repeated cycles of Odonata extinction and recolonisation on the island, preventing the persistence of populations for long enough to develop endemic insular characters. If this has been so then the Cypriot dragonfly fauna might be expected to contain a relatively high proportion of species which are quick to colonise and (in view of the island's poor habitat diversity), are more generalist, less specialised, in their habitat preferences.

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