Searching for exuviae of endemic Odonata species in Greece

C. Brochard & E. van der Ploeg

Introduction

Only a few major papers have been published on the Odonata fauna of Corfu (Sutton, 2009) and Crete (Battin, 1989). In 2010, an atlas of the Odonata of Greece was published by Lopau (2010) which comprises almost all available records. Most papers only deal with the endemic or the Critically Endangered species of these islands. Kalkman & Lopau (2006) describe the morphological differences between *Pyrrhosoma nymphula* and *P. elisabethae* for both male and female adults and present an overview of the distribution of *P. elisabethae*. Although the imagines of *Boyeria cretensis* were described two decades ago (Peters, 1991), the description of the larva of this species was published only very recently by Müller et al. (2012). It is remarkable that a study on the behaviour of the imagines was undertaken (Schneider & Müller, 2006) before the larva was known. The larva and exuvia of *Coenagrion intermedium* were described by Battin (1991), one year later than the adults (Lohmann,1990). Jödicke (2005) conducted a study on the distribution of *Coenagrion intermedium* on Crete. He also provided information on the coloration, niche specificity and reproduction behaviour of that species.

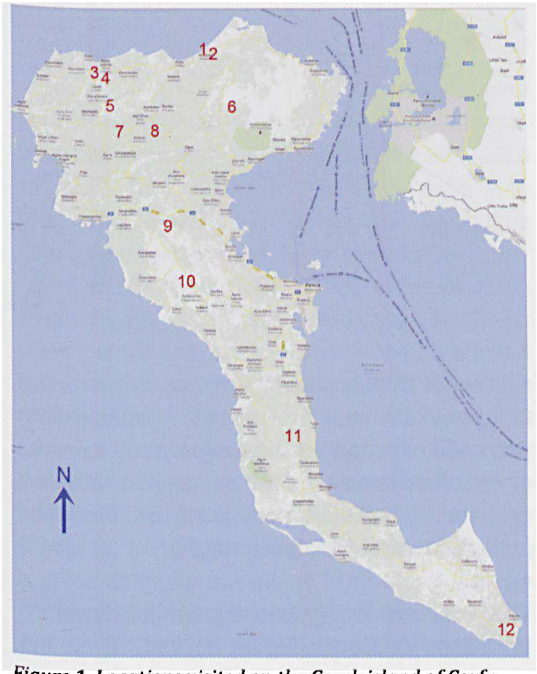

Figure 1. Locations visited on the Greek island of Corfu.

In 2010, we started a project to create a photographic guide for exuviae of European dragonflies, in which we hope to provide identification keys for the exuviae of all European Odonata species. One of the major difficulties of such a project is to collect or locate exuviae of all these species. These are required not only for taking photographs for the book, but also for taking the necessary measurements to differentiate between closely related species. In such cases many individuals are needed for statistical validation of identification criteria. To add to the project's difficulties, the knowledge of exuviae of dragonflies in south eastern Europe is poor, as illustrated by e.g. *P. elisabethae*, of which the larva and exuvium have only recently been discovered (Brochard & Van der Ploeg, 2012).

For the endemic species, insufficient material was available. We therefore decided to go on a field trip to some of the Greek islands in order to collect larvae and exuviae of these rare and threatened dragonflies.

In May 2012, we surveyed the Greek island of Corfu (or Kerkira) with the intention to find *P. elisabethae*, a species endemic to Greece and Albania. In June 2012 we visited the island of Crete, with the aim of collecting exuviae of the endemic species *C. intermedium* and *Boyeria cretensis*. In this article we present the results of these two trips.

Figure 2. Locations visited on the Greek island of Crete.

Material & Methods

Collecting exuviae

The search for exuviae, especially of rare species, can be difficult. This is not only because exuviae may be difficult to find in the field, but also because information on precise locations where the species occur is either not there or not clearly given in publications. Fortunately, such information is at least partly available for *C. intermedium* (Jödicke, 2005), *P. elisabethae* (Kalkman & Lopau, 2006) and for *B. cretensis* (Müller et al., 2012). We also made use of the publication of Lopau (2010).

One of the most difficult aspects of searching for exuviae is to be in the right place at the right time of the year. If you arrive too early in the season, only larvae are present and if you are too late, larvae have emerged and exuviae may have disappeared. Weather conditions make the search for exuviae even more difficult as wind and rain can affect emergence and will have effects on the preservation of the exuviae in the following days. A touch of luck is vital for the search to be successful.

Most imagines could be identified visually or with the help of binoculars. If necessary, an insect net was used to catch individuals for identification in the hand. Exuviae were found by looking for suitable places for emergence. The collected exuviae were stored in small plastic boxes and put in a freezer for at least 12 hours in order to make sure that no insects or spiders could damage them. The larvae were caught by use of a scoop net and were kept in a cool box during fieldwork. An aquarium and photographic equipment were sent to both islands in order to take photographs of living larvae. We did not sex the specimens in the field (adults, exuviae or larvae) because we wanted to spend most of our time searching for exuviae. Sexing of larvae is not always as easy as for most species of the family Libellulidae (Brochard et al., 2012). A GPS was used to locate the sites we would like to visit, and to georeferate the newly investigated locations.

Localities

The selection of the sites we wanted to visit was based on the known or suspected occurrence of *P. elisabethae* on Corfu and on the known or suspected occurrence of *C. intermedium* and *Boyeria cretensis* on Crete. This information was partly found in Lopau (2010) and Müller et al. (2012), or was kindly provided to us by Vincent Kalkman, Jean-Pierre Boudot and Fons Peels. Additional locations were selected by analysing topographical maps and satellite images for the presence of suitable biotopes for these species, or for other species of which we had only few exuviae in our collection, such as *Trithemis annulata* and *Selysiothemis nigra*.

This resulted in 12 investigated locations on the island of Corfu (Figure 1) and 18 on the island of Crete (Figure 2). They are numbered

Locations on the island of Corfu

Loc. 1: Dune ponds, 2 km northwest of Pithos, 300 m from the coast, Corfu;
N39° 48.711' E19° 50.394'; 12 May 2012.
In the most northerly dunes of Corfu, some dune ponds can be found about 300 meters south of the shoreline. The ponds are very shallow and as a result, the temperature of the water was high. At these ponds, reeds, grasses and sedges emerged from the water in high density (Figure 3). These ponds were very rich in nutrients, due to intensive grazing by cattle.

Loc. 2: Dune ponds, 1.5 km northwest of Vasilika and 800 m from the coast, Corfu; N39°48.467' E19°50.580'; 13 May 2012.

Loc. 3: Melissoudi River, 1 km south-southeast of Sidari, Corfu; N39°46.603' E19°43.040; 6 May 2012, 9 May 2012 and 12 May 2012.
The Melissoudi River flows in a northerly direction to the sea and has a sandy substrate. This river is bordered by a line of trees and bushes (Figure 4), with an abundant undergrowth of brambles and nettles. Locally, reeds are present along the banks. As a consequence, the river is at least partly overshadowed for most of the day. In May 2012 the river was flowing slowly, with some small and shallow rapids. The slow-flowing parts were deeper, with some stretches deeper than 1.5 m. In wintertime the depth of the river sometimes exceeds 10 metres, causing the water to be channelled through the valley at high speed.

Loc. 4: Garden, 1.7 km west-southwest of Karousades, Corfu; N39°46.502' E19°43.505'; 7 May 2012.

Loc. 5: River, 900 m east of Kopsochilades, Corfu; N39°45.304' E19°43.811'; 10 May 2012.

Loc. 6: Water reserve, 370 m east-northeast of Petalia on mount Pantokrator, Corfu; N39°45.121' E19°50.630'; 13 May 2012.

Loc. 7: Small brook, 650 m north-northeast of Drosato, Corfu; N39°44.328' E19°44.374'; 10 May 2012.
Near Drosato, a small stream comes out of a densely wooded area and flows alongside an allotment. Over a length of about 30 m, the stream is fully exposed to the sun, and only about 0.3 m wide, with a depth of approximately 5 cm, (Figure 5). Upstream from this shallow stretch, the stream is wider (2 m) and deeper (over 1 m) and completely shaded. Downstream, the water flows through two concrete culverts beneath an unpaved road and continues as a two metre wide, shallow river, which is overgrown with grasses and herbs and surrounded by trees and shrubs.

Loc. 8: River, 450 m southwest of Kipriandes, Corfu; N39°44.240' E19°45.759'; 12 May 2012.

Loc. 9: Small lakes, 1 km northwest of Poulades, Corfu, N39°40.059' E19°47.166', 7 May 2012.
These natural lakes (Figure 6) in the hills near Poulades have a well-developed aquatic vegetation and are surrounded by fields and forests.

Loc. 10: Small river, 1.9 km east-northeast of Giannades, Corfu; N39°38.225' E19°47.099'; 7 May 2012.

Loc. 11: River, 1.3 km west of Episkopiana, Corfu; N39°29.925' E19°54.285'; 11 May 2012.

Loc. 12: Water reservoir, 1.3 km southwest of Kavos, Corfu; N39°22.437' E20°06.357'; 9 May 2012.
This man-made reservoir is situated in the far southeast of the island and is characterised by the presence of many boulders on the shore (Figure 7). Riparian vegetation is only marginally present. The edges of the reservoir are quite steep and it is thought to be several metres deep in the middle. The surrounding landscape holds a mix of grasslands, forest and bramble bushes.

from north to south for Corfu and from west to east for Crete. For each of these 30 sites, the name of the nearest village is given. Whenever possible the name of the river, pond or lake is added. This is followed by the GPS coordinates (Latitude, Longitude using WGS 84 projection) and the date of observation. For both islands we describe the most interesting locations.

Results and annotations on some species

Altogether 37 species of Odonata were observed on Corfu and Crete. On Corfu, more than 1,700 exuviae of 24 species were collected. Six more species were observed only as imagines (Table 1). On Crete, 23 species were noted and more than 5,800 exuviae of 19 species were collected (Table 2).

Locations on the island of Crete

Loc. 13: Lake Kourna, west of Kavallos, Crete; N35°19.892' E24°16.540'; 20 June 2012.

Loc. 14: River 200 m northeast of Filaki, Crete; N35°19.190' E24°19.600'; 20 June 2012.

Loc. 15: Kabanos River, 1 km east of Koufi, Crete; N35°18.935' E24°21.555'; 21 June 2012.
This small river is surrounded by forests and its streambed is dominated by large stones, resulting locally in small rapids (Figure 8). In general, however, the river flows quite slowly over most of its course. The depth of the river is variable, with the deepest stretches at least 1.5 m deep. The river is bordered by trees. Large tangles of submerged tree roots along the river banks provide an ideal habitat for dragonfly larvae.

Loc. 16: Petres River, 2 km northwest of Kaloniktis, at both sides of a bridge, Crete; N35°18.872' E24°22.492'; 19 June 2012, 20 June 2012 and 24 June 2012.
The Petres River (Figure 9), close to location 15, provides a more diverse selection of habitats, compared to the Kabanos River. The habitat is often quite similar to that in the Kabanos River, but the Petres River also contains a large number of rocky rapids as well as deep and slow-flowing parts with overhanging trees and submerged roots. Some sections of river are fully exposed to the sun, while others are in deep shade. This combination results in suitable habitats for many different dragonfly species.

Loc. 17: River near Mili, bridge, Crete; N35°20.252' E24°30.235'; 19 June 2012.

Loc. 18: Pool west of Amari Reservoir, west of Voleones, Crete; N35°16.560' E24°33.727'; 21 June 2012.

Loc. 19: Pool north of Amari Reservoir, west of Voleones, Crete; N35°17.210' E24°33.993'; 21 June 2012.

Loc. 20: Amari Reservoir, Metochi Chadzigrigori, 1.5 km northwest of Voleones, Crete; N35°17.148' E24°34.480'; 19 June 2012.
This artificial lake was created in 2009 by damming the Stavromana River (Figure 10). The reservoir is characterised by a sandy substrate, its perimeter gradually sloping to the middle of the lake, which is probably several metres deep. After about three years, the first vegetation has now established itself in the water and along the borders of the lake.

Loc. 21: River, 1 km west of Voleones, Crete; N35°16.342' E24°34.748'; 21 June 2012.

Loc. 22: River, 500 m west of Amari, Crete; N35°13.690' E24°38.593'; 23 June 2012.

Loc. 23: River, 100 m east of Lambiotes, Crete; N35°12.978' E24°41.442'; 23 June 2012.

Loc. 24: Laloumas Reservoir, southeast of Skourvoula, Crete; N35°05.667' E24°51.133'; 22 June 2012.
This artificial lake (Figure 11) of about 1.5 km long and at most 0.5 km wide, has been created by damming the Paridhokefala River. It is characterized by shallow edges with fringes of reed, and has only locally aquatic vegetation.

Loc. 25: Reservoir, 500 m southwest of Armanogia, Crete; N35°07.322' E25 09.548';
27 June 2012.
This relatively small lake was created in 2009 by damming the small Tris Potami River. Due to the very recent formation of the lake, aquatic and riparian vegetation (Figure 12) is almost completely absent apart from some fringes of reed. The substrate of the lake is sandy.

Loc. 26: Amourgelon Reservoir, 1.5 km southeast of Amourgeles, Crete; N35°07.253' E25 11.348'; 26 June 2012.

Loc. 27: Partira Reservoir, 600 m west of Mikri Episkopi, Crete; N35°07.650' E25°12.815'; 26 June 2012.

Loc. 28: Ini Machera Reservoir, northeast of Machera, Crete; N35°05.437' E25°16.528';
26 June 2012.

Loc. 29: Small river and pools, northeast of Demati, Crete; N35°02.158' E25°17.690';
27 June 2012.

Loc. 30: Bramiana Reservoir, 2 km east of Kalogeri, Crete; N35°02.078' E25°41.793';
27 June 2012.

Table 1. *Records of dragonflies, exuviae and larvae on Corfu: adults, exuviae and larvae. This table shows the sum of adults (a), exuviae (e) and larvae (l) for each species at each location.*

Species	Loc1	Loc2	Loc3	Loc4	Loc5	Loc6	Loc7	Loc8	Loc9	Loc10	Loc11	Loc12
Calopteryx virgo			1l		3e		40a,3e, +100l	40a, 11e				
Lestes barbarus		8a,64e							3a,+100l			
Chalcolestes parvidens									25l			
Coenagrion puella			3a									
Coenagrion pulchellum			3a									
Coenagrion scitulum									4a			1a,1e
Crocothemis erythraea	2e								4a			3a,2e
Erythromma lindenii												+100a,+100e, +100l
Erythromma viridulum	25a											30a
Ischnura elegans	+100a,1e		16a,11e						10a			+100a
Pyrrhosoma elisabethae			104a,348e,6l									
Platycnemis pennipes			85a,46e		6e		8a,+100l	1a			6a,1e	
Aeshna affinis	12e	2e								+50l		
Anax imperator	1a,15e		1a			1a,15e						4a,13e
Anax parthenope				1a								10a,7e
Brachytron pratense			15a,7e						3a			
Caliaeschna microstigma					1e		1a,7e	1a,13e				
Gomphus schneiderii							3a,37e,2l	65e				
Onychogomphus forcipatus							+100l					
Somatochlora meridionalis							2l					
Libellula depressa						1a,2e	1a	1a				
Libellula fulva			23a,53e		4e		1a,1e				25a,38e	
Orthetrum brunneum	1a,38e											
Orthetrum cancellatum									4a			30a
Selysiothemis nigra												163e,4l
Sympetrum fonscolombii	30a,64e											
Sympetrum meridionale		40a										
Sympetrum striolatum		5a										
Sympetrum striolatum/ meridionale	53e	367e							30l			
Trithemis annulata												9a,180e,1l

Coenagrion intermedium

C. *intermedium* (Figure 18) is an endemic species for Crete that has been found at several localities on the island (Jödicke, 2005; Lopau, 2010). We found the species at six locations, always co-occurring with *B. cretensis*. This seems to indicate that they have the same habitat requirements. The highest numbers of *C. intermedium* were found at the Kabanos River (loc. 15) and at the Petres River (loc. 16). At the Kabanos River 50 imagines were observed and just over 80 exuviae were collected. At the Petres River 275 imagines were observed and over 500 exuviae were collected. A short sampling with a scoop net at the latter location revealed over 50 larvae (Figure 19), which were mainly found in submerged vegetation and among submerged tree roots. This corresponds very well with the description given in Jödicke (2005).

Coenagrion scitulum

No recent populations were known for the islands of Corfu and Crete (Lopau, 2010). The nearest populations are found on mainland Greece and on some islands at less than 100 km away from Crete or Corfu. We were able to find populations of *Coenagrion scitulum* both on Corfu and Crete. On Corfu *C. scitulum* was found at some small lakes near Poulades (loc. 9) and at a water reservoir near Kavos (loc.

Table 2. *Records of dragonflies, exuviae and larvae on Crete: adults, exuviae and larvae.*
This table shows the sum of adults (a), exuviae (e) and larvae (l) for each species at each location.

Species	Loc13	Loc14	Loc15	Loc16	Loc17	Loc18	Loc19	Loc20	Loc21	Loc22	Loc23	Loc24	Loc25	Loc26	Loc27	Loc28	Loc29	Loc30
Calopteryx splendens		+100a,4e	+100a,23e	200a,50e	20a					30a,29e	+100a,33e							
Chalcolestes parvidens				121a,186e,+100l		2e	318e			2e	20a	7a,1e						
Sympecma fusca														+100a,274e			7a,93e	
Ceriagrion tenellum				1a														
Coenagrion intermedium		10a	50a,81e	275a,518e,50l	20a					5a,4e	20a,19e							
Coenagrion scitulum												10a						
Erythromma lindenii	5e																	
Erythromma viridulum												+1,000a	2a	10a	8a	50a	2a	40a
Ischnura elegans	1a		10a	24a		50a		30a					+100a	10a	15a	10a	+100a	50a
Aeshna mixta							25e	1e				16e		1e				
Anax imperator			1a	3a		4a,10e	5a	5a			1a	50a	3a	1a	1a	2a	2a	
Anax parthenope						1a	2a	5a				200a	1a	3a	5a	7a		2a,6e
Boyeria cretensis		5a,7e	3a,101e	30a,577e,50l	9e				5e	2a,3e	4a,30e							
Lindenia tetraphylla												10a,413e,1l	2a,4e	2a,1e	1a,2e	2a,20e		
Crocothemis erythraea			1a	3a,2e		3a,1e	3a					500a,360e		1a	4a	4a	2a	
Orthetrum brunneum				5a									3a			1a	30a,15e	2a
Orthetrum cancellatum	1a,8e					10a,2e		2a,46e				30a,13e	15a	3a,1e	5a,25e	6a		8a
Orthetrum coerulescens			5a,1e	60a,36e						1a,4e	5a,12e							
Selysiothemis nigra												+1,000a,608e	1a					2a
Sympetrum fonscolombii						1e		7e				4e				15e	3e	50a
Sympetrum meridionale																	2a	
Sympetrum striolatum																2a	4a	
Sympetrum striolatum/ meridionale						2e		9e				10e						6e
Trithemis annulata	1a,3e		3a	16a,38e		25a,1e	50a	10,000a,1,395e				+10,000a,337e	+100a	25a,3e	+100a	+100a		+100a,10e

Figure 3. Nearly overgrown dune pond near Pithos, Corfu (loc. 1) (Photo: Christophe Brochard).

12). At the latter a freshly emerged individual was found next to its larval skin, offering proof of successful reproduction of *C. scitulum* on Corfu. No evidence of reproduction was found at the small lakes nearby Poulades, but it is very likely that it also reproduces here. After more than 100 years, *C. scitulum* was rediscovered on Crete by Andrew Chambers in May 2012 at a lake just north of the village of Agia (N35°28.577' E23°55.987'). At this location, he observed and photographed a tandem of *C. scitulum*. About a month later, we observed about ten specimens, mating and ovipositing at the dam lake of Laloumas (loc. 24), which lies 100 km east of Agia. Therefore we may conclude that at least two local populations are present on Crete. The species was first mentioned for Crete by Selys & Hagen (1850), without reference to the exact location. Since then, the species had not been seen anymore and was therefore considered as extinct on Crete (Lopau, 2010).

Erythromma lindenii

Another new species for Corfu was *Erythromma lindenii*. This species was discovered at the water reservoir near Kavos (loc. 12). Imagines of *E. lindenii* as well as larvae and exuviae were found in large numbers, offering proof of a strong local population. The species is well known and present at many sites on the mainland of Greece (Lopau, 2010). Our discovery of a population at a water reservoir was therefore not unexpected, but we were surprised by the high number of adults, larvae and exuviae. We expect that *E. lindenii* might be present at other sites on Corfu as well.

Pyrrhosoma elisabethae

The only place on Corfu where we found *P. elisabethae* was at the Melissoudi River (loc. 3) near Sidari, where it was present only along a few hundred meters of this river. We collected nearly 350 exuviae (Figure 15) and caught six larvae. Also, many emerging individuals (Figure 13) and more than 100 imagines were observed. Larvae and exuviae of *P. elisabethae* had not been described before (Brochard & Van der Ploeg, 2012), but our findings will make it possible to study them in detail and to describe the exuviae. Our results amply exceed the four imagines collected by Lopau in 1998 (Kalkman & Lopau, 2006). At the Melissoudi River (loc.

Figure 4. Melissoudi River near Sidari, Corfu (loc. 3), habitat of Pyrrhosoma elisabethae *(Photo: Christophe Brochard).*

Figure 5. Small brook near Drosato (Corfu) with concrete culverts in the background (loc. 7) (Photo: Christophe Brochard).

Figure 6. One of the small lakes 1 km northwest of Poulades, Corfu (loc. 9) (Photo: Christophe Brochard).

Figure 7. Water reservoir near Kavos, Corfu (loc. 12) where Selysiothemis nigra *is present (Photo: Christophe Brochard).*

Figure 8. Kabanos River east of Koufi, Crete (loc. 15). Habitat of Boyeria cretensis *and* Coenagrion intermedium *(Photo: Christophe Brochard).*

Figure 9. Petres River, near Kaloniktis, Crete (loc. 16). Habitat of Boyeria cretensis *and* Coenagrion intermedium *(Photo: Christophe Brochard).*

Figure 10. Amari Reservoir, Metochi Chadzigrigori, northwest of Voleones, Crete (loc. 20) (Photo: Christophe Brochard).

Figure 11. Laloumas Reservoir near Skourvoula, Crete (loc. 24), locality with a population of Lindenia tetraphylla *(Photo: Christophe Brochard).*

Figure 12. Water reservoir near Armanogia, Crete (loc. 25) in Crete (Photo: Christophe Brochard).

13), *P. elisabethae* was the most common dragonfly species. Accompanying species were *Platycnemis pennipes, Ischnura elegans, Brachytron pratense* and *Libellula fulva*, all present in good numbers. Although we looked for *P. elisabethae* at other potentially suitable habitats on the island, we were not able to find another population, indicating that the species might be rare on Corfu. Some locations on Corfu formerly known to hold *P. elisabethae* are now so heavily polluted by sewage that it seems improbable that they still hold populations of this species. Some rivers and small streams are densely overgrown by bamboo. Roots of other trees (*Salix* sp. & *Alnus* sp. for example) are absent, leaving no suitable options for oviposition. *P. elisabethae* could also not be found at another locality formerly known to hold the species, a river 1.3 km west of Episkopiana (loc. 11). Although *L. fulva* and *P. pennipes* were still present, this river also is now probably too heavily polluted for *P. elisabethae*. *P. elisabethae* is a critically endangered species (KALKMAN ET AL., 2010). As a consequence, even small local changes or modifications in its habitat have great impact on the global status of the species.

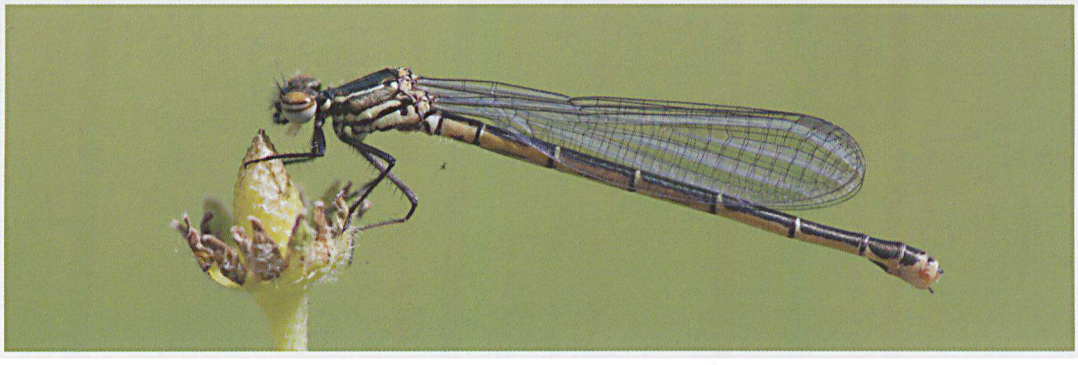

Figure 13. Immature female of Pyrrhosoma elisabethae*, 6 May 2012, Melissoudi River, Corfu (loc. 3) (Photo: Christophe Brochard).*

Boyeria cretensis

B. cretensis (Figure 17) was found at seven locations on the Island of Crete. The highest numbers were observed on the Kabanos River (loc. 15) and the Petres River (loc. 16) where respectively three imagines and 101 exuviae and 30 imagines and 577 exuviae were observed or collected. Most of the sightings of imagines concerned patrolling males, continuously flying in the shade along the river banks. Some ovipositing females were also observed. Although we focused on collecting exuviae, a brief sampling with a scoop net in the Petres River revealed easily 50 larvae (Figure 20). These were mainly found in tangles of tree roots hanging down along the river banks. With a very few exceptions, exuviae of *B. cretensis* were found in shaded places, such as tree roots and overhanging rocks. The number of collected exuviae is exceptionally high; historical records give numbers of about 200 larvae being collected over a period of three years (MÜLLER ET AL., 2012).

Gomphus schneiderii

The rheophile species *G. schneiderii* was found at two localities on Corfu. At a small brook near Dorsato (loc. 7), three adults, 47 exuviae and two larvae were found and at a river southwest of Kipriandes (loc. 8) only exuviae (n = 65) were found.

Lindenia tetraphylla

A newly discovered species and the first Gomphidae species reported for Crete is *Lindenia tetraphylla* (BOUDOT ET AL., 2009; LOPAU, 2010).

Both exuviae and imagines were found at five lakes in the central part of the island. First, two exuviae of *L. tetraphylla* were found on 22 June, immediately north of the western end of the dam of Laloumas Reservoir (loc. 24). Later, an intensive investigation of a large section of the lake resulted in a total of 413 exuviae and one fully grown larva, ready to emerge. On the same day we observed one tandem and more than ten adults. This is an indication that the emerging

Figure 14. Female Selysiothemis nigra, *Reservoir, 500m southwest of Armanogia, Crete (loc. 25), 27 June 2012 (Photo: Christophe Brochard).*

Figure 15. Exuviae of Pyrrhosoma elisabethae, *6 May 2012, Melissoudi River, Corfu (loc. 3) (Photo: Christophe Brochard).*

Figure 16. Larva of Lindenia tetraphylla, *22 June 2012, Laloumas Reservoir, Crete (loc. 24) (Photo: Christophe Brochard).*

Figure 17. Freshly emerged female of Boyeria cretensis, *21 June 2012, Kabanos River, Crete (loc. 15) (Photo: Christophe Brochard).*

Figure 18. Male Coenagrion intermedium, *21 June 2012, Kabanos River, Crete (loc. 15) (Photo: Christophe Brochard).*

period may be quite long, something which has also been noted in Montenegro (De Knijf et al., 2013). Throughout its range, adults have been observed from March to October, depending on the latitude (Schorr et al., 1998). Other places where the species was found are a lake near Armanogia (loc. 25), Amourgelon Reservoir (loc. 26), Partira Reservoir (loc. 27) and Ini Machera Reservoir (loc. 28). At all these reservoirs, both adults and exuviae were found, but not as numerous as at Laloumas Reservoir. Of the locations on Crete where *L. tetraphylla* was found, Laloumas Reservoir (loc. 24) produced the highest number of specimens by far. All these reservoirs are the result of damming small rivers and streams, some only a few years ago. The reservoir, 500 m southwest of Armanogia (loc. 25) for example, was created in 2009. Surprisingly, *L. tetraphylla* is already reproducing in these recently created habitats. It is supposed that the species has a larval life (Figure 16) of at least one year (Suhling & Müller, 1996), which would mean that the species colonised the most recently created reservoir within two years after it was created.

Somatochlora meridionalis

Somatochlora meridionalis is known from a few locations on Corfu (Lopau, 2010). We caught two larvae in a small brook near Drosato (loc. 7). Unlike its congener *Somatochlora metallica* in Western and Central-Europe, the larvae of *S. meridionalis* were found in a very shallow, fast flowing part of the stream.

Selysiothemis nigra

S. nigra was found on both Corfu and Crete at only four localities in total. On Corfu, it was

Figure 19. Larva of Coenagrion intermedium, *19 June 2012, Petres River, Crete (loc. 16) (Photo: Christophe Brochard).*

found at one location, namely a water reservoir near Kavos (loc. 12). At this water reservoir, 163 exuviae and four larvae were collected but imagines were not observed. On Crete, the species was detected at three localities. At Laloumas Reservoir (loc. 24) over 600 exuviae were collected, but only a few adults (Figure 14) could be found along the edge of the lake. A few hundred metres from the water, adults were present in high numbers on a cornfield, hunting for prey and partners. This behaviour was also witnessed on Corfu, where no adults were present at the lake.

Trithemis annulata

At some lakes on Crete, *T. annulata* was present in exceptionally high numbers, such as at Amari Reservoir (loc. 20), where more than 10,000 adults were seen. Based on the numbers of collected exuviae, this must be considered as a conservative estimate of the total number of individuals. At less than 1% of the perimeter of the lake, almost 1,400 exuviae were collected. The species was also very abundant (>10,000 adults) at some other sites, for example at Laloumas Reservoir (loc. 24).

Discussion

Identification of *Gomphus schneiderii*

Adults of *G. schneiderii* are easily confused with the very similar *Gomphus vulgatissimus*. Dijkstra & Lewington (2008) state that one of the field characters for the identification of *G. schneiderii*, is the presence of blue eyes rather than greenish eyes. However, the three observed adults on Corfu all had greenish eyes (Figure 21) and so resembled G. *vulgatissimus*. This was also observed for the specimens found in Montenegro (De Knijf et al., 2013). This could easily lead to confusion and misidentification of *Gomphus* species in southeastern Europe. De Knijf et al. (2013) give structural differences to discriminate between both species. Since adults are difficult to identify in the field, exuviae and larvae may sometimes help in clinching the identification of *Gomphus* species present at a certain location. The exuviae of *G. schneiderii* and *G. vulgatissimus* are relatively easy to separate. In *G. schneiderii* segment six does not have lateral spines, whereas in *G. vulgatissimus* lateral spines are present on this segment (Suhling & Müller, 1996). Based on the absence of a lateral spine on both sides of segment six, all 100 collected exuviae of *Gomphus* species on Corfu could be identified as *G. schneiderii.* The fact that the eyes of *G. schneiderii* are green in the western part of its range, may suggest that a hybrid population could be present (J.P. Boudot, pers. comm.). Because eye colour seems not to be a reliable criterion, structural characters should be checked (De Knijf et al., 2013). We also examined the genitalia of the some adults, in order to identify the specimens as either *G. Schneiderii* or *G. vulgatissimus*. The genitalia of the captured adults appeared to fully comply with those known for *G. schneiderii.* Furthermore, the exuviae that we examined did not show intermediate criteria such as having the lateral spine of segment six only at one side, or having very small lateral spines. *G. vulgatissimus* is not known to be present on Corfu. For these reasons we find it difficult to believe that *Gomphus* populations on Corfu could be of hybrid origin. Nevertheless, more research (e.g. genetical comparison of both *Gomphus* species) is needed in order to prove or contradict that the population of Corfu belongs to *G. schneiderii.* Also more research on exuviae is needed in order to define all the identification features for discerning between the exuviae of *G. vulgatissimus* and *G. schneiderii.*

Why search for exuviae

The results presented in this paper show that estimates of the population size for Odonata species should not only be based on the numbers of observed adults, but also on the collection of exuviae. For example, a maximum of 104 adults of *P. elisabethae* were counted along the Melissoudi River on Corfu (loc. 3), whereas 348 exuviae were found. This location was visited three times and the overall count of 104 adults was the sum of all these visits. Obviously, this number of observed specimens could be unreliable as one individual might have been recorded more than once. On the other hand, exuviae were collected on each occasion,

Figure 20. Larva of Boyeria cretensis, 19 June 2012, Petres River, Crete (loc. 16) (Photo: Christophe Brochard).

making double counting impossible. Also on Corfu, at the water reservoir southwest of Kavos (loc. 12), 163 exuviae and four larvae of *S. nigra* were found, while no adults were observed. Of course there is no best way of estimating a population size. It is nearly impossible to count all adults, but this is also the case when searching for exuviae. Exuviae are sometimes difficult to find because the larvae might not yet have emerged, or the exuviae could have been washed or blown away during bad weather. It is clear that the most reliable results for estimating

Figure 21. Male Gomphus schneiderii *with greenish eyes, 10 May 2012, Drosato, Corfu (loc. 7) (Photo: Christophe Brochard).*

a population size may be obtained using a combination of methods, something which has also been proposed by RAEBEL ET AL. (2010). Without taking exuviae into consideration, the number of *B. cretensis* and *L. tetraphylla* would have been greatly underestimated in our survey. Exuviae research is also invaluable where, for whatever reason, adults are hard to find. Imagines of the endemic *B. cretensis* are not easily encountered in the field. We counted a total of 30 adults of *B. cretensis* at the Petres River (loc. 16) and some of them were probably counted several times. On the other hand, 577 exuviae were collected. The same goes for *L. tetraphylla* on Crete. At Laloumas Reservoir (loc. 24) only about ten adults were observed, while 413 exuviae were collected. The first record of this species for Crete was that of an exuvium rather than a sighting of an adult specimen. Similar results were obtained for *Caliaeschna microstigma* (a total of 21 exuviae and two imagines) and *G. schneiderii* (a total of 102 exuviae and three imagines) on Corfu. We were also able to collect 43 exuviae of *Aeshna mixta* on Crete, but not even a single adult was observed.

Acknowledgements

We would like to thank Vincent Kalkman, Fons Peels and Richard Seidenbusch for their advice, and Jean-Pierre Boudot for his advice and very useful comments on this paper. Without their assistance the trips would not have achieved this success. We want to thank Andrew Chambers for allowing us to use his observation of *Coenagrion scitulum* on Crete and publish his discovery in this article. We are very grateful to the Schure-Beijerinck-Popping fund that financed the trip to Corfu and to the Uyttenboogaart-Eliasen Stichting for financial support for the trip to Crete. We also thank Antony and Marilyn Guest on Corfu, and Stratos Kapetanaki and his family on Crete, for their hospitality. We wish to sincerely thank David Chelmick for his editing assistance. Finally we would like to thank Geert De Knijf for his advice and the great improvement of this paper.

Christophe Brochard
Marsstraat 77
9742EL Groningen
info@cbrochard.com

Ewoud van der Ploeg
Slauerhofflaan 60
9752HD Haren gn
agrius_convolvuli@hotmail.com

References

Battin, T., 1989. Überblick über die Libellenfauna der Insel Kreta (Insecta: Odonata). Zeitschrift der Arbeitsgemeinschaft Österr. Entomologen 41: 52-64.

Battin, T., 1991. Description of the larva of *Coenagrion intermedium* Lohman, 1990 from Crete, Greece (Zygoptera: Coenagrionidae). Odonatologica 20: 333-336.

Boudot, J.P., V.J. Kalkman, M. Azpilicueta Amorín, T. Bogdanović, A. Cordero Rivera, G. Degabriele, J.-L. Dommanget, S. Ferreira, B. Garrigós, M. Jović, M. Kotarac, W. Lopau, M. Marinov, N. Mihoković, E. Riservato, B. Samraoui & W. Schneider, 2009. Atlas of the Odonata of the Mediterranean and North Africa. Libellula Supplement 9: 1-256.

Brochard, C., D. Groendijk, E. van der Ploeg & T. Termaat, 2012. Fotogids Larvenhuidjes van Libellen. KNNV uitgeverij, Zeist.

Brochard, C. & E. van der Ploeg, 2013. Een eerste kennismaking met de larven van de Turkse koraaljuffer en de Griekse vuurjuffer. Brachytron 15(2): 133-139.

De Knijf, G., C. Vanappelghem & H. Demolder, 2013. Odonata from Montenegro, with notes on taxonomy, regional diversity and conservation. Odonatologica 42(1): 1-29.

Dijkstra, K.-D.B., & R. Lewington (illustraties), 2008. Libellen van Europa: Veldgids met alle libellen tussen Noordpool en Sahara. Tirion Uitgevers BV, Baarn, 1e druk.

Jödicke, R., 2005. Bemerkungen zu *Coenagrion intermedium* (Odonata: Coenagrionidae). Libellula Supplement 6: 15-24.

Kalkman, V.J. & W. Lopau, 2006. Identification of *Pyrrhosoma elisabethae* with notes on its distribution and habitat (Odonata: Coenagrionidae). International Journal of Odonatology 9: 175-184.

Kalkman, V.J., J.-P. Boudot, R. Bernard, K.-J. Conze, G. De Knijf, E. Dyatlova, S. Ferreira, M. Jović, J. Ott, E. Riservato and G. Sahlen, 2010. European Red List of Dragonflies. Luxembourg: Publications Office of the European Union.

Lohmann, H., 1990. *Coenagrion ponticum intermedium* subspec. nov. von der Insel Kreta, Griechenland (Odonata: Coenagrionidae).

Opuscula Zoologica Fluminensia 54: 1-7.

Lopau, W., 2010. Studien zur Libellenfauna Griechenlands IV. Libellula Supplement 10: 1-260.

Müller, O., U. Taron, A. Jansen & T. Schneider, 2012. Description of the larva of *Boyeria cretensis* Peters and comparison with *B. irene* (Fonscolombe) (Anisoptera: Aeshnidae). Odonatologica 41(1): 47-54

Peters, G., 1991. Die Schattenlibelle auf Kreta (*Boyeria cretensis* spec. nov.) und die Monophylie der "Gattung" *Boyeria* McLachlan, 1896. (Odonata Anisoptera, Aeshnidae). Deutsche Entomologische Zeitschrift 38: 161-196.

Raebel, E.M, T. Merckx, P. Riordan, D.W. Macdonald, D.J. Thompson, 2010. The dragonfly delusion: why it is essential to sample exuviae to avoid biased surveys. Journal of Insect Conservation 14: 523-533.

Schneider, T. & O. Müller, 2006. Der Endemit *Boyeria cretensis*: Beobachtungen zur Verhaltensbiologie der Imagines (Odonata: Aeshnidae). Libellula 25: 135-146.

Schorr, M., W. Schneider & H. Dumont, 1998. Ecology and distribution of *Lindenia tetraphylla* (Insecta, Odonata, Gomphidae): a review. International Journal of Odonatology 1: 65-88.

Selys Longchamps, E. de & H.-A. Hagen, 1850. Revue des Odonates d'Europe. Ouvrage servant de complément et de supplément à la Monographie des Libellulidées d'Europe. Mémoires de la Société royale des Sciences de, Liège 6: I-XII, 1-408, 4 Pl.

Suhling, F. & O. Müller, 1996. Die Flußjungfern Europas (Gomphidae). Die Neue Brehm-Bücherei 628, Magdenburg (Westarp-Wissenschaften).

Sutton P.G., 2009. A checklist of the dragonflies (Odonata) of Corfu (Kérkira) including a new record for the Ionian Islands, the Black Pennant *Selysiothemis nigra* (Vander Linden, 1825). Bulletin of the Amateur Entomologists' Society 68(485): 136-144.

Summary

Brochard, C. & E. van der Ploeg, 2013. Searching for exuviae of endemic Odonata species in Greece. Brachytron 15(2): 83-101.

During two field trips to Greece in 2012, the first to Corfu in May 2012 and the second to Crete in June 2012, 37 species of dragonflies were observed. On Corfu, many larvae and exuviae of *Pyrrhosoma elisabethae* were found, both unknown to science. On Crete a fair number of exuviae of *Coenagrion intermedium* and *Boyeria cretensis* were collected. *Coenagrion scitulum* and *Erythromma lindenii* are reported for the first time for Corfu and *Lindenia tetraphylla* was a new species of the dragonfly fauna of Crete. Also on Crete, *Coenagrion scitulum* is rediscovered at two localities after an apparent absence of more than 100 years. The identification of *Gomphus schneiderii* and the use of searching for exuviae are discussed near the larval habitat.

Samenvatting

In dit artikel worden de resultaten besproken van twee reizen naar Griekenland. In mei 2012 werd een bezoek gebracht aan Corfu en in juni 2012 werd Kreta bezocht. Tijdens deze twee reizen werden in totaal 37 soorten libellen waargenomen. Zowel op Corfu als op Kreta werden bijzondere ontdekkingen gedaan. Op Corfu werden meer dan 300 larvenhuidjes van de Griekse vuurjuffer (*Pyrrhosoma elisabethae*) gevonden. Op Kreta werden ruim 600 huidjes verzameld van de Kretawaterjuffer (*Coenagrion intermedium*) en ongeveer 750 larvenhuidjes van de Kretaschemerlibel (*Boyeria cretensis*). Naast deze vondsten werden op beide eilanden soorten ontdekt die er niet eerder zijn aangetroffen. Op Corfu werden de Gaffelwaterjuffer (*Coenagrion scitulum*) en de Kanaaljuffer (*Erythromma lindenii*) ontdekt. Op Kreta werd de Vaandeldrager (*Lindenia tetraphylla*) op verschillende plaatsen aangetroffen. Niet alleen is dit een nieuwe soort voor Kreta, het betreft ook de eerste rombout die op het eiland is aangetroffen. Op Kreta werd ook een tweede kleine populatie van de Gaffelwaterjuffer ontdekt.

Keywords:

Odonata, Greece, Corfu, Crete, exuviae, larva, *Pyrrhosoma elisabethae, Coenagrion intermedium, Coenagrion scitulum, Erythromma lindenii, Boyeria cretensis, Gomphus schneiderii, Lindenia tetraphylla.*