BULLETIN OF THE ENTOMOLOGICAL SOCIETY OF MALTA (2013) Vol. 6 : 5-127

An overview of the dragonflies and damselflies of the Maltese Islands (Central Mediterranean) (Odonata)

Godwin DEGABRIELE[1]

ABSTRACT. Seventeen species of odonates have been recorded on the Maltese Islands of which *Pantala flavescens* represents a new record. Diagnostic features of the adult and larval stages of these species are described in this work. The work also combines findings from previous literature on Maltese Odonata with information gathered from fieldwork data in order to give an insight on the current situation of the Odonata of the Maltese Islands and serves as an identification guide to both adults and larvae of these insects. The anatomy and physiology of the larval and adult forms of these insects, which are discussed in this work, are adapted to the predatory lifestyle which they lead. The fact that odonate larvae frequent different habitats from adults helps to reduce competition for resources. Adult odonates can be found in a number of local habitats, mostly near freshwater but also brackish water bodies since freshwater is a scarce natural resource on the Maltese Islands. Global warming is affecting the distribution range of odonates in the Mediterranean - while some species may be on the decline, others which can thrive in hot dry environments are progressively being recorded in the Mediterranean and southern Europe, including the Maltese Islands. Relatively little work on the Odonata of the Maltese Islands has been done previous to the present work. Most of this involves listing of locally recorded species; very little research investigates odonate behaviour and distribution. No information exists as to why species such as *Sympetrum striolatum*, and *Orthetrum cancellatum* have become progressively uncommon in recent years, and therefore more research is required on the matter. Because of limiting water resources, freshwater habitats on the Maltese Islands are quickly drained of water, which may be used for agricultural purposes. This may tend to reduce species richness of local odonates. Biologists are now considering dragonflies as biological indicators of a healthy environment and make recommendations in order to preserve the habitats frequented by these insects.

KEY WORDS. Biology, habitats, global warming, human impact, *Pantala flavescens*.

PREAMBLE. Dragonflies and damselflies are insects which, though relatively easy to observe, have not been extensively studied on the Maltese Islands. They are beautiful creatures, and because, as recent research has revealed, they can be used as bio indicators as well as monitors of the quality of freshwater habitats, they are worth preserving as part of the local natural ecosystems.

The main aim of this work is to give a detailed overview of the Odonata of the Maltese Islands, as well as to serve as an identification guide for the species. It first gives an account of the anatomy, biology and aspects of the ecology of the organisms, and then describes each locally recorded

[1] Department of Biology, Junior College, University of Malta, Msida MSD 1252, Malta. E-mail: godwin.degabriele@um.edu.mt

species, giving its status, together with physical and behavioural features and also diagnostic features of adults and larvae. Photographic illustrations of all of the species are included, while distribution maps for each species give an idea of the range of the species on the Maltese Islands. Various drawings of anatomical structures highlight distinctive features which might not appear clearly in photographs. Also included are vernacular names in Maltese for all the species. Furthermore, this work gives an account of the history of the study of local Odonata referring to all previous work on the subject to date. Finally, it describes the scientific value of dragonflies and damselflies to humans as well as the local impact which humans are leaving on these organisms.

It is hoped that with the present work one gets a better awareness of these insects and their habitats, and also an awareness of the importance of conserving them.

INTRODUCTION

The Order Odonata is very diverse, with around 6,000 species (Corbet & Brooks, 2008) of rather large insects collectively known as dragonflies. These insects are amongst the most primitive invertebrates capable of flight (Silsby, 2001; Abbott, 2005; Corbet & Brooks, 2008). The word Odonata, or "toothed ones" (Tillyard, 1917; d'Aguilar *et al*., 1986; Corbet & Brooks, 2008), refers to the mouthparts, typical of these insects, which they use to capture prey and to hold it whilst devouring it (Tillyard, 1917).

The name "dragonflies" is also used to refer to the insects of the Suborder Anisoptera. Thus, in order to avoid confusion, many biologists use the word "odonates" when speaking about insects of the Order Odonata, and the word "dragonflies[1]", or "true dragonflies", when speaking about anisopterans (Silsby, 2001; Abbott, 2005; Dijkstra & Lewington, 2006). This naming system will also be followed in this work.

Although fossil records show that around 300 million years ago, during the Palaeozoic era, primitive odonates were extremely large[2], with wingspans reaching over 600 mm, modern odonate wingspans range from 20 mm in the Far Eastern zygopteran *Agriocnemis femina* (Coenagrionidae) and the South-East Asian dwarf anisopteran (Libellulidae) *Nannophya pygmaea* (Silsby, 2001), to a wingspan of 190 mm in the South American zygopteran (Pseudostigmatidae) *Megaloprepus caerulatus* and 200 mm in the South-East Asian anisopteran (Aeshnidae) *Tetracanthagyna plagiata*.

Odonata classification

The Order Odonata belongs to the Phylum Arthropoda, the Class Insecta and Subclass Pterygota, or "winged insects". This Order is traditionally subdivided into the Suborder Zygoptera (equal wings); Anisoptera (subequal wings) and Anisozygoptera, a Suborder with two extant Asiatic species, the rest being extinct. Anizozygopterans are described by some authors (e.g. Silsby, 2001; Brooks, 2002; Dijkstra & Lewington, 2006) as having body features of anisopterans, with damselfly-like wings but also as having exclusive unique features[3]. Recent authors (e.g. Corbet & Brooks, 2008; Rehn, 2003; Bechly & Poinar, 2013) argue that the members of the Suborder Anizozygoptera

[1] Corbet & Brooks (2008) refer to anisopterans as "warriorflies".

[2] Fossils of *Meganeura monyi* dating from 300 my ago, show a wingspan of 670 mm.

[3] e.g. eyes separated by less than the width of an eye, and broad-bodied larvae which breathe through rectal gills but are unable to move by jet propulsion (Silsby, 2001).

should be grouped differently from the above described system[4].

The Suborder Zygoptera, or damselflies, includes mostly smallish, slender species with a relatively weak flight. This Suborder is subdivided into 19 extant families (Dijkstra & Kalkman, 2012). The three[5] zygopteran species recorded from the Maltese Islands belong to the families Calopterygidae (demoiselles; Dijkstra & Lewington, 2006) and Coenagrionidae (bluetails, bluets, brighteyes, and red damsels; Dijkstra & Lewington, 2006).

The Suborder Anisoptera, or 'true' dragonflies, includes medium-sized to large, robust, fast flying insects. This Suborder is further subdivided into 12 extant families (Corbet & Brooks, 2008; Dijkstra & Kalkman, 2012). The 16 anisopteran species that have been recorded from the Maltese Islands belong to the families Aeshnidae (hawkers, emperors, and spectres; Dijkstra & Lewington, 2006) and Libellulidae (chasers, skimmers, whitefaces, darters, dropwings, groundlings, perchers, pennants, gliders and cascaders; Dijkstra & Lewington, 2006).

Differences between the Suborders Zygoptera and Anisoptera are summarized in table 1 (pg. 41), whereas detailed descriptions of Zygopteran and Anisopteran species are to be found in the species description section (pp. 47-95).

Evolution and fossil records

It is not clear whether Odonata evolved alongside the Ephemeroptera (mayflies), or the Neoptera - which include insects with a modern wing organization[6] (Rehn, 2003). Although fossil evidence and some morphological and molecular characters suggest that the extant Orders Odonata and Ephemeroptera (mayflies) belong to the most primitive group of winged insects, the Palaeoptera[7], the rather strong characters of the extant head morphology and some molecular data suggest that Odonata and Neoptera are grouped under Metapterygota (Bechly, 2003).

The earliest odonate fossil records date from the Upper Carboniferous period, some 325 million years ago (Silsby, 2001; Corbet & Brooks, 2008). These include large extinct species which are classified under a number of the primitive groups such as Protodonata and Geroptera. The wings of these extremely large primitive insects lacked the wing spot, or pterostigma, and the wing notch, or nodus (or node), typically found in most modern Zygoptera and Anisoptera. The Protodonata disappear from fossil records towards the end of the Permian (around 245 million years ago; Brooks, 2002). Fossil records also indicate that the first forms of Zygoptera, Anisoptera and Anisozygoptera appeared about 250 million years ago in the Permian era (d'Aguilar *et al*., 1986; Miller, 1995; Brooks, 2002). Some species which date from these times had already developed features found in modern odonates (Fig. 1).

[4] Corbet & Brooks (2008) argue that the members of the Suborder Anisozygoptera are all extinct, and classify present day members of this Suborder under the family Epiophlebiidae, placed under the Suborder Anisoptera. Bechly, (1996, in Bechly & Poinar, 2013) proposes that Anisoptera and Epiophlebioptera (to include members of the Anizozygoptera) should be grouped under Epiprocta.

[5] Two of these three species, belonging to the genus *Calopteryx*, are recorded only from old collected material and are considered to be vagrants in this work.

[6] Neopteran insects are able to flex their wings over the body when at rest.

[7] In almost all cases these insects have: a wing mechanism which prevents the wings to fold flat over the body; and an aquatic larva (Miller, 1995; Askew, 2004; Corbet & Brooks, 2008).

Figure 1: *Aeschnogomphus intermedius* - an example of an extinct Anisopteran from the Upper Jurassic in Germany. This species has a pterostigma and nodus, which represent typical features found in modern day odonates.

Adult anatomy

In order to be able to properly identify between different odonate species, it is important that one has some anatomical knowledge of such insects. The odonate body is designed for efficient capture of prey in mid air. Typical odonate features include minute antennae, prominent eyes, two pairs of transparent membranous, densely veined wings, and a stream-lined body. Figures 2 and 3 represent a typical damselfly and dragonfly respectively, with the most important morphological features labelled.

The odonate head (Fig. 4a-d) is mostly concerned with sensory and feeding functions. One of the most prominent features is a pair of prominent compound eyes composed of many small ommatidia. The eyes are confluent in all locally occurring anisopteran species, but not in Zygoptera. The top back part of the head is known as the occiput. In Coenagrionidae, the occiput has two brightly coloured post ocular spots. In species with confluent eyes, the occiput has been reduced to the occipital triangle. In front of the eyes is a region known as the vertex. This structure lies in front of the occiput and behind the the anterior part, or the frons.

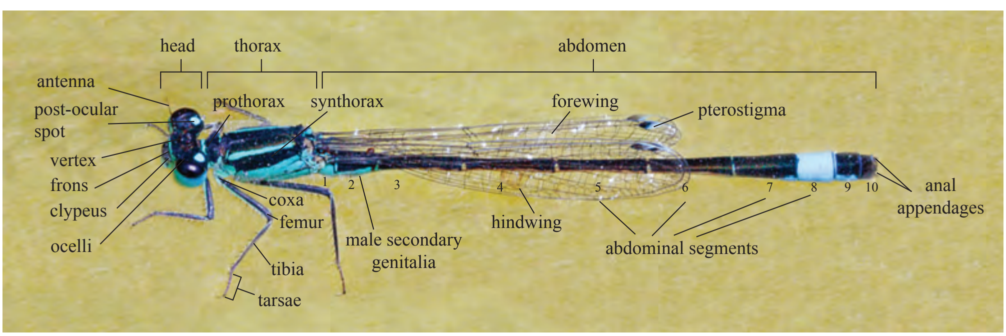


Figure 2: General anatomy of a zygopteran (Coenagrionidae: *Ischnura genei* - male).

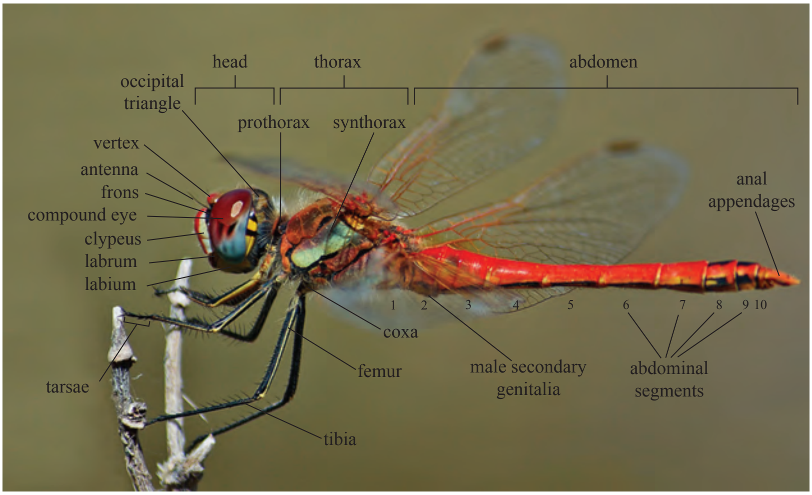
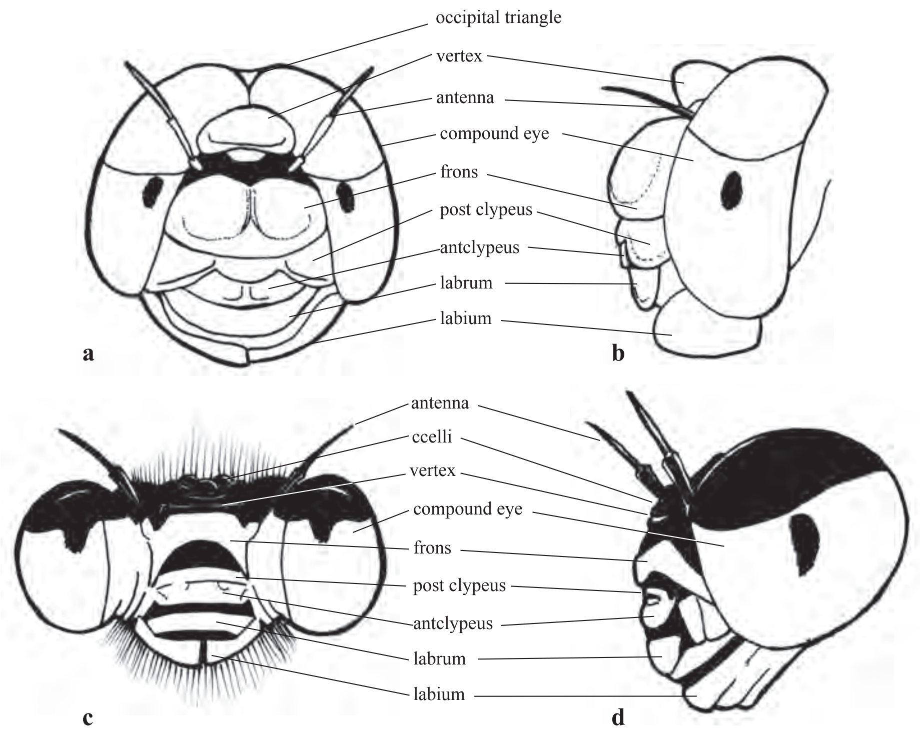
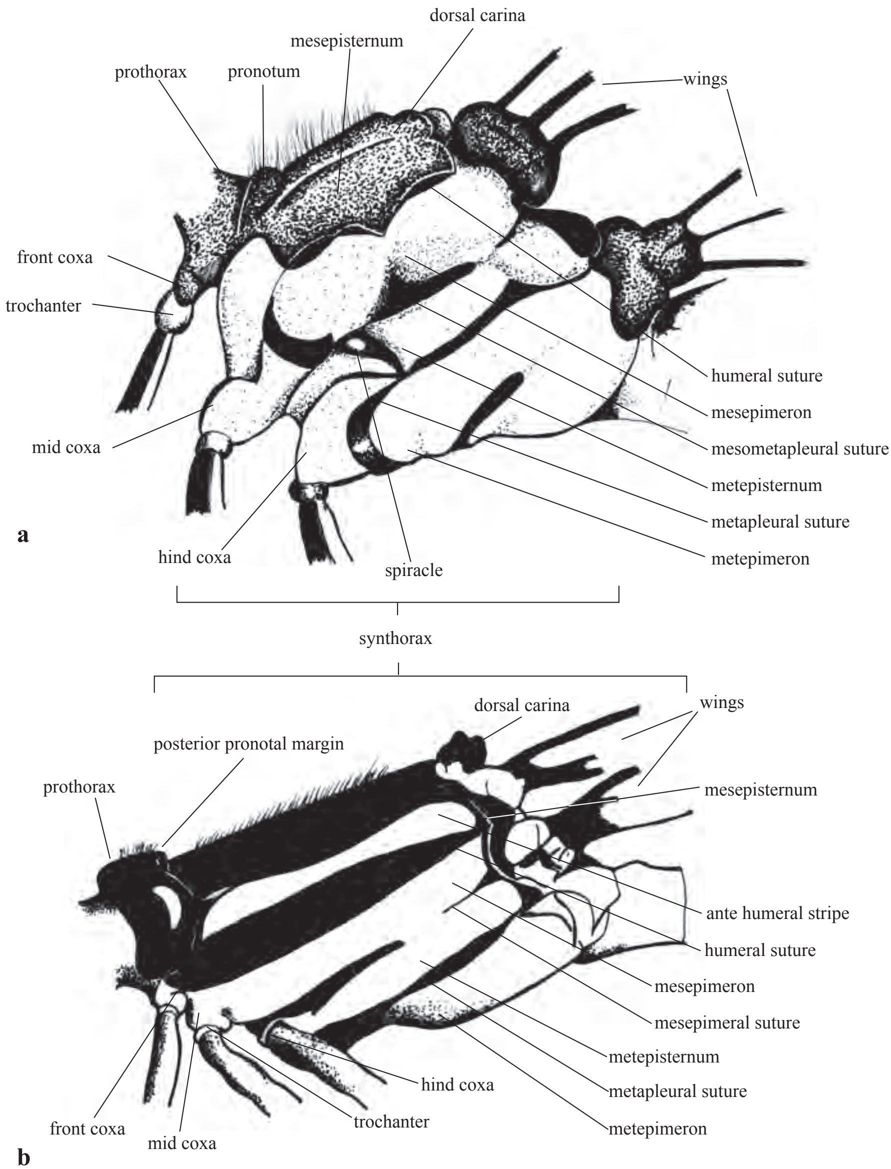


Figure 3: General anatomy of an anisopteran (Libelluliidae: *Sympetrum fonscolombii* - male).



Figures 4a-d: Odonate heads including basic morphological characteristics. **a** and **b**: *Sympetrum striolatum* (front and lateral view); **c** and **d**: *Ischnura genei* (front and lateral view).

The occipital region usually contains three ocelli (simple eyes), used for detecting light (Abbott, 2005; Dijkstra & Lewington, 2006). Short segmented antennae spring from the region in between the vertex and the frons. In many anisopterans, the vertex is raised to form a protuberance. The clypeus, found below the frons and above the labial region, consists of two plates, namely the post - and antclypeus. The lower part of the front underneath the clypeus includes the labrum or upper lip, the mandibles which chew the food and the three-lobed labium (Fraser, 1957) or lower lip, which



Figures 5a-b: Odonate thorax showing main morphological features. **a**: Anisoptera (*Sympetrum striolatum*); **b**: Zygoptera (*Ischnura genei*).

covers the lower section of the mandibles. Mandibles are hinged sideways and shear through prey like a pair of serrated scissors (Brooks, 2002). The head is connected to the thorax by two chitinous plates, or sclerites, which permit great mobility (Silsby, 2001). This feature, as well as the wide range of vision provided by the large eyes make the dragonflies good predators.

The thorax (Figs. 5a-b) is mostly concerned with locomotory functions. It is divided into two sections. The first, or prothorax, is the smaller segment. It joins anteriorly with the head, and posteriorly with the second section, known as the synthorax or pterothorax. The upper part of the prothorax, or pronotum, differs in shape depending on species and sex, and can be an important identification feature in some species particularly zygopterans. The prothorax also carries the anterior pair of legs.

The synthorax is the larger section of the thorax. When viewed laterally, the connections between the segments of this section seem to slope backwards. On the middle section of the synthorax, in front of the wing bases, lies the highest point of the thorax, known as the dorsal carina or dorsal crest. In Anisoptera, this often carries a keel or spine. The synthorax consists of the meso- and metathoracic segments each of which are further divided into an episternum and epimeron. All of these sections are divided by clearly visible humeral sutures. The middle segment, or mesothoracic epimeron, is partly divided by the mesometapleural suture. In some species, the mesepisternum is marked in the middle by a band of colour known as the antehumeral stripe. The humeral suture may also have a similar band of coloration known as the humeral stripes. The antehumeral and humeral stripes are diagnostic features important when distinguishing between similar species (e.g. in Coenagrionidae). The synthorax carries a pair of clear wings with complex venation attached to each of the mesothoracic and metathoracic epimera; the synthorax also carries the middle and hind pairs of legs. The ventral region of the thorax is covered by three plates known as sternites. A pair of thoracic spiracles are found below the metepisternum.

Odonates have legs typical of all insects (Fig. 6), with a coxa that links to the upper leg or femur via the trochanter. The femur in turn links directly to the lower leg or tibia. This structure ends in a multi-segmented tarsus with a terminal claw. All legs point forward and are designed for perching and hunting.

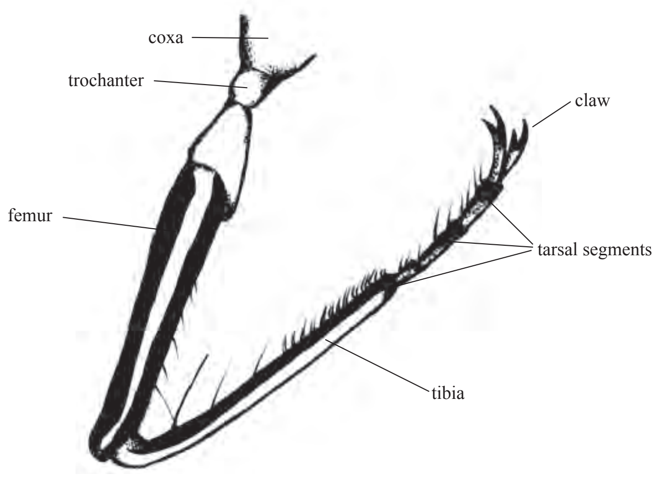
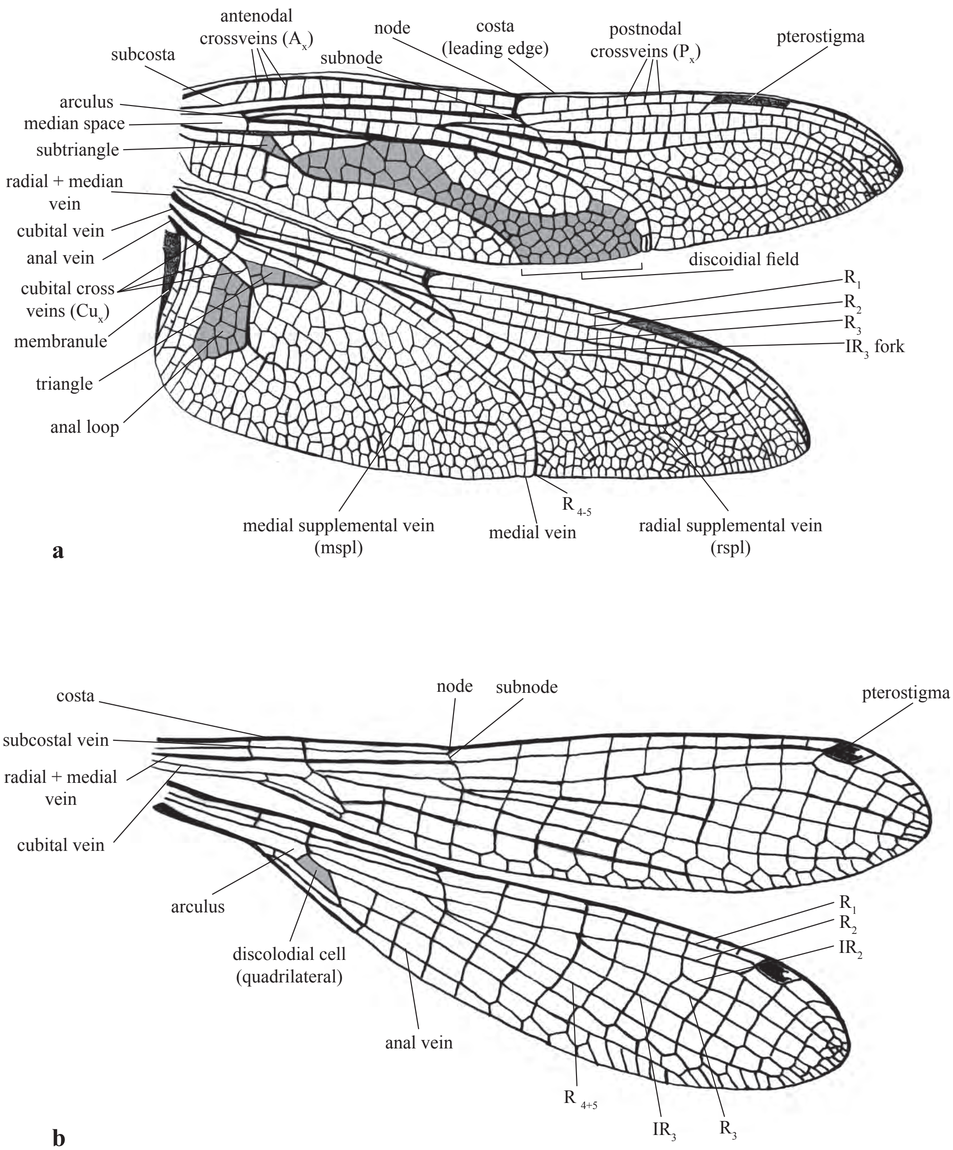


Figure 6: Odonate leg (*Sympetrum striolatum*) with main morphological characteristics.

Abbreviations of terms describing wing structures (Figs. 7a-b) largely follow DIJKSTRA & LEWINGTON (2006). Odonate wings are described as hyaline (glassy, clear and transparent). In some species (including some local ones) wings can have coloured areas. Odonate wing venation, often diagnostic of species, is rather complicated, particularly in anisopterans. Veins stretch out longitudinally along the wing and provide support. They are linked by a number of crossveins. Areas of wing membranes are surrounded by veins are known as cells. There are five main veins

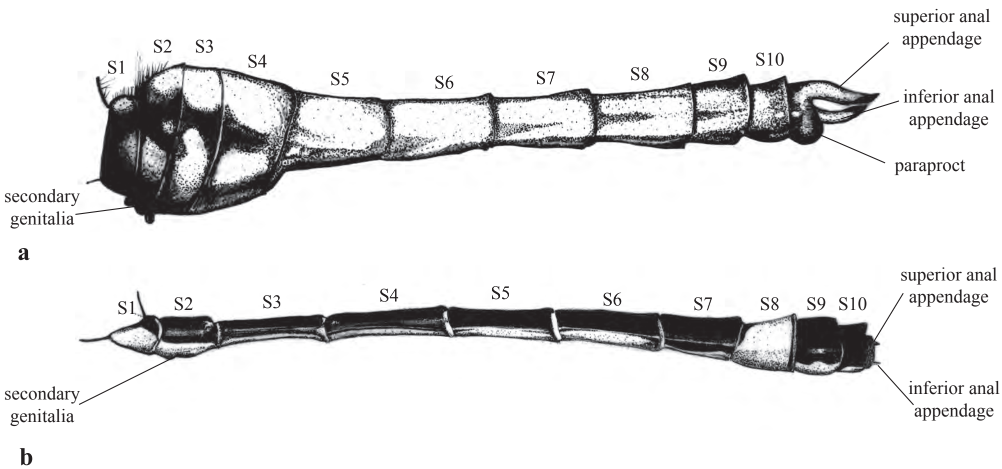


Figures 7a-b: Odonate wings. **a**: Anisoptera (*Anax imperator*); **b**: Zygoptera (*Ischnura genei*).

in each wing: the upper two being the costa, or costal vein and the subcosta, or subcostal vein; the radius - and - median, found in the middle region of the wing; the cubitus, and the anal vein in the posterior region of the wing. The anterior edge of the wing is supported by the costa. In present day odonates, the wings are divided into two main areas by the node which forms a notch on the anterior side of the wing. The position of the node varies with different species, being nearer the wing base in zygopterans, towards the middle in some anisopterans (e.g. aeshnids) and towards the wing tip in other anisopterans (e.g. libellulids). The node lies in the middle of the topmost or costal vein (also known as the costal margin or leading edge) and moves to the right until the second radial vein. This region is known as the subnode. The subcosta ends at the subnode. The radius-and-median veins are fused at the wing base. The radius runs along the length of the wings, while the median branches via a bent vein known as the arculus. The region enclosed under the medial vein, with the arculus on one side and thoracic region to the other is known as the median space. In most anisopterans there are no crossveins in this space. The arculus lies almost half way in the antenodal region and to the right of the medius, and forms the anterior side of a region of cells known as the discoidal cell. The arculus then curves downwards as the anterior median vein towards the posterior edge of the wing. The area of cells which extends from the triangle distally towards the wing border between the cubital and anal veins is known as the discoidal field. The area between the radial and medial vein is supported by the radial sector. This branches into five veins known as: the radius 2 (R_2); the infra radial vein 2 (IR_2); the radius 3 (R_3); the infra radial vein 3 (IR_3); and the radial vein 4 (R_4, which is also fused with radial vein 5 or R_5). Underneath IR_3 is another vein known as the radial supplemental vein (rspl). The number of rows of cells in this region varies and is an important diagnostic feature of some families and species. In Anisoptera, the medial supplemental vein (mspl) extends from the discoidal cell under the R_5 vein. The cubital vein extends from the base of the wing to the discoidal cell (forming the posterior side of the dicoidal cell in zygopterans, and the basal side of the triangle in anisopterans). It then curves down towards the posterior margin of the wing. In zygopterans, the anal vein is fused with the posterior wing border at the wing base, separating at the region of the arculus and running parallel to the cubital vein. In anisopterans, the anal vein can lead to a region known as the anal loop or anal field. The shape of the cells in this region differs greatly from the cells outside the anal loop. This area is also diagnostic of some species. The anisopteran wing also possesses a membranule, a roughly triangular opaque membrane on the posterior side of the wing. It is larger and more conspicuous in the hindwing. In males of some dragonfly genera (e.g. *Aeshna*) the area of cells adjacent to the membranule in the direction of the wing tip make up a triangular shape known as the anal triangle.

Between the costa and radius veins lie a number of crossveins. The two rows of crossveins that link the costa, subcosta and radius between the wing base and the nodus are known as the antenodals (A_x). The rows of veins may or may not be aligned depending on the family. The number of these crossveins also varies with species. In Zygoptera, with the exception of calopterygids, there are only two primary antenodal veins. The distal antenodal (the antenodal crossvein just before the nodus) may be complete (from costa to radius) or incomplete (from costa to subcosta) in some libellulids. A row of crossveins links the costa directly to the radius between the nodus to the wing tip. These crossveins are known as the post nodals (P_x). In modern odonates, with the exception of calopteriygids, a pigmented cell is found after the last post nodal crossvein known as the pterostigma thought to aid in the of control wing movement during flight, by acting as an inertial regulator of wing twisting (Askew, 2004). Other important crossveins include those that connect the cubital vein with the anal vein, known as the cubital crossveins (Cu_x). These veins stop at a region known as the triangle. The cubital crossveins lie on top of the anal loop or anal field. Towards the tip of the wings, the veins of the radial sector are typically connected to a series of intercalated veins. The region of discoidal cell is referred to as the quadrilateral in zygopterans, and as the hypertriangle plus triangle in anisopterans. The zygopteran quadrilateral is enclosed between the medial (anteriorly) and cubital (posteriorly) and two crossveins; a distal crossvein and the lower portion of the arculus on the other side. In anisopterans, the discoidal cell is divided into the hypertriangle and the triangle by a crossvein. A subtriangle proximal to the triangle can also occur in some species.

The odonate abdomen (Figs. 8a-b) is made up of ten cylindrical segments (S1-10 from base to tip) terminating in anal appendages. In some libellulids, the segments can be dorso-ventrally flattened. Each segment is covered by a dorsal convex tergite and a ventral sternite. In females, abdomens tend to be generally stouter than in males. The first abdominal segment (S1) is conical in shape, with the narrower side joining the metathoracic epimeron to the abdomen. S2[8] is somewhat more swollen than S1, while S3 is longer and tends to narrow in some Anisoptera, particularly in libellulids. S4-7 are long, tubular almost identical segments, S8-9 shorter, while S10 is usually smaller and tapered inwards. The anal appendages are attached to S10. A pair of spiracles occurs on S1-8. Male odonates always have secondary genitalia on the ventral side of S2 and S3, while in females, S9 contains the genital opening on the ventral side. Moreover in females of endophytic species, there is an ovopisitor on S8-9, while females of exophytic species have a vulvar scale or plate on S8. Anal or caudal appendages (Fig. 9a-b) are used by males to clasp females by the head (in Anisoptera) or by the pronotum (in Zygoptera). They consist of a pair of superior (upper) dorsal appendages (cerci) in both Anisioptera and Zygoptera, and two inferior (lower) ventral appendages[9] in Zygoptera and only one in Anisoptera (epiproct).

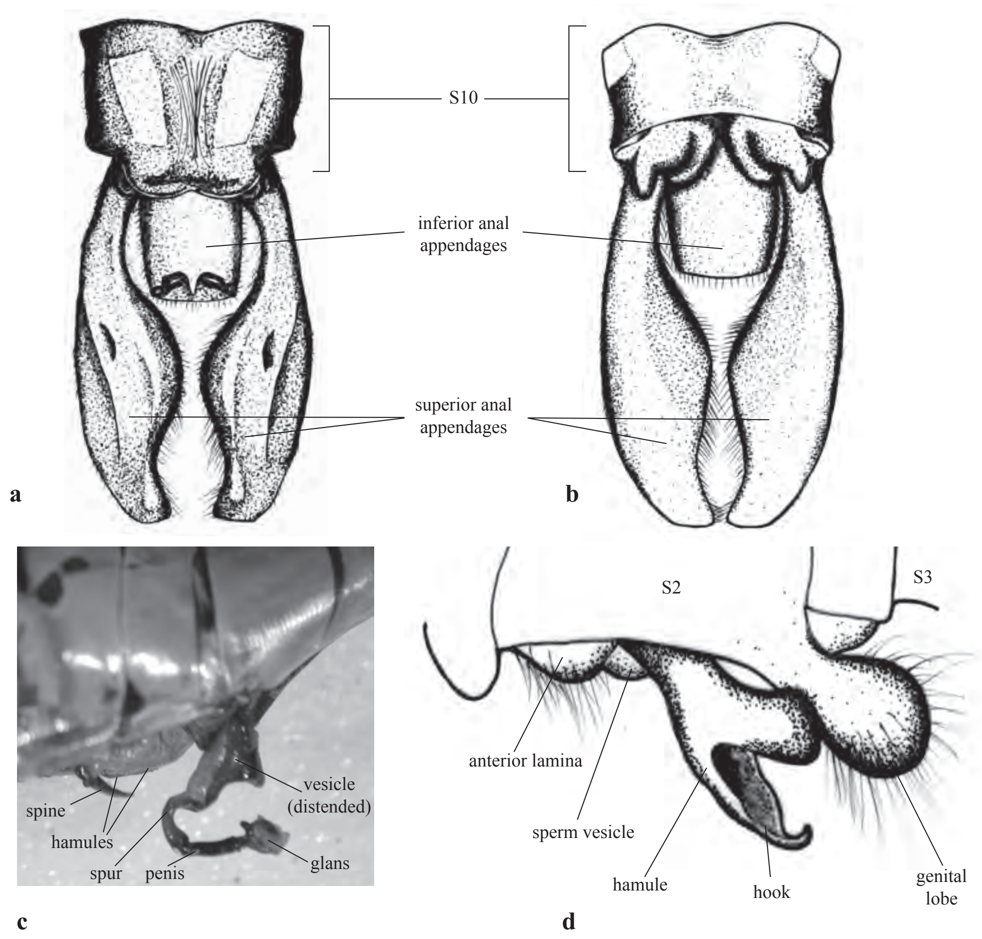


Figures 8a-b: Odonate abdomens with main morphological features. **a**: Anisoptera (*Trithemis annulata* - male); **b**: Zygoptera (*Ischnura genei* - male).

A pair of testes are found in S9 of males. These make up the male primary genitalia. Because the anal claspers in males are situated in the close proximity of the primary genitalia, it is not possible for the genitalia to transfer sperm cells to the female. The problem is solved by males evolving secondary genitalia (Fig. 9c-d), situated ventrally in S2 and specifically designed to transfer sperm into the female whilst the mating pair is in the heart position (Fig. 11e). Sperm is therefore transferred from

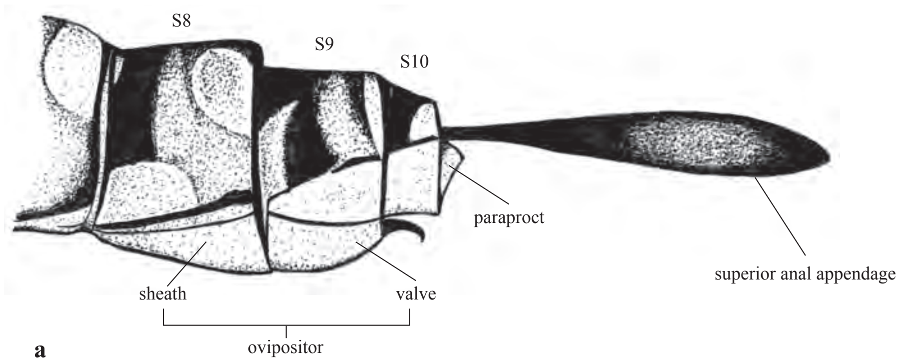
[8] In some aeshnids (e.g. *Aeshna*) S2 also carries a pair of side swellings known as auricles, thought to guide the female to locate the male secondary genitalia while copulating.
[9] Situated above the anus.

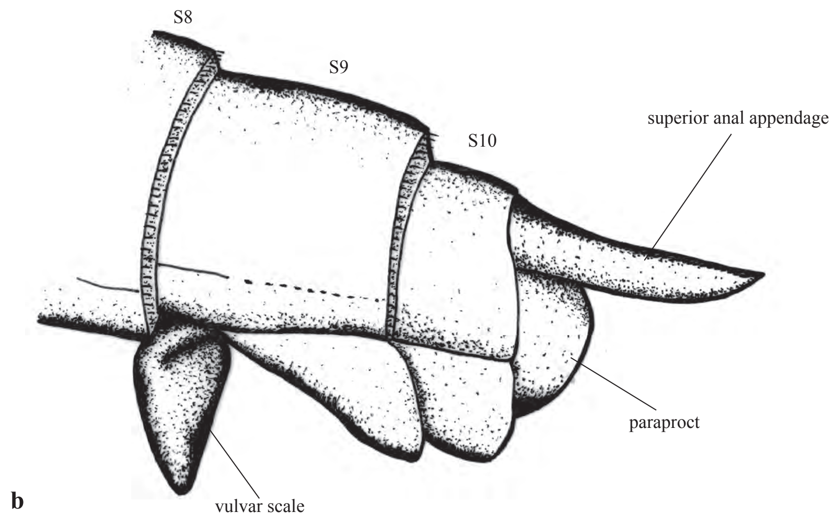
the testis to the penis, found within the region of the secondary genitalia, prior to mating. Secondary genitalia consist of an anterior lamina (laminar plate) which is a transverse frontal structure and a pair of hamules or grasping organs. In libellulids, the hamules are made up of an anterior hook and a posterior lobe. The genital lobes, also found in the secondary genitalia consist of two ventral expansions which extend behind the hamules. These expansions contain a three-segmented penis which is folded in the ligule when not in use (Fig. 9c, which shows the penis distended). The shape of the secondary genitalia is unique and can be a diagnostic feature to identify closely related species e.g. *Orthetrum brunneum* and *O. coerulescens anceps*.



Figures 9a-d: Anisopteran male anal appendages and secondary genitalia including main morphological features. **a** & **b**: anal appendages of *Anax imperator* (a - dorsal; b - ventral); **c**: secondary genitalia of *Anax parthenope* with vesicle distended showing penis and glans; **d**: secondary genitalia of *Sympetrum striolatum*.

Primary genitalia in females (Fig. 10a-b) are found on S8-9. During mating, sperm is transferred here from the male secondary genitalia. In endophytic species, namely zygopterans and aeshnid anisopterans, females are also equipped with an ovipositor and three pairs of serrated valves which are situated on S8+9. These are designed to dig tunnels into vegetation or debris in order to deposit the ova within the tunnel. In exophytic species such as libellulids, the ovipositor is greatly reduced and merely transformed into a vulvar scale or plate situated on S8. The vulvar scale is lip - or spout - like in shape and serves as a chute along which eggs are released from the body of the female. The shape of the vulvar scale is also unique and can be a diagnostic feature to identify closely related species e.g. *Sympetrum fonscolombii*, and *S. striolatum*. Females have no secondary genitalia and this feature helps in identifying the gender of a specimen, particularly, in the case of immature males or old females.





Figures 10a-b: Anisopteran female genitalia including main morphological characteristics. **a**: endophytic type (*Aeshna mixta*); **b**: exophytic type (*Crocothemis erythraea*).

Adult life functions

In order to understand odonate behaviour it is important to learn about their life functions. Some aspects of these are discussed in this section.

Both adults and larvae lead a predatory lifestyle, feeding mostly on invertebrates, particularly other insects. Many authors (e.g. Askew, 2004; Corbet & Brooks, 2008) define odonates as "obligate" and "opportunistic" predators. Odonates tend to focus foraging behaviour where the probability of predator prey encounters are high (Corbet & Brooks, 2008). Their body features are adapted to such a predatory lifestyle, namely: (i) wings which enable strong flight; (ii) mouths that feature a retractable upper lip, or labrum, which in turn covers a set of tooth-like mandibles, suitable for biting chunks off the prey and; (iii) legs, which are located near the head and point forward, ideal for perching and for catching prey.

Body temperature control in odonates occurs by means of several behavioural strategies which increase or reduce the body surface area exposed to the sun as required. Strategies which increase heat absorption can include: (i) spreading their body in the direction of the sun when they need to warm up; (ii) whirring their wings by shivering wing muscles so as to generate heat; (iii) basking on rocks, tree trunks, and bare soil - substrates which typically radiate heat; (iv) adopting a temperature-dependent change in body colour intensity from lighter in warmer climates to darker in colder ones thus aiding in faster absorption of heat by black body radiation (Silsby, 2001; Brooks, 2002; Askew, 2004; Corbet, 2004) and; (v) choosing to roost in the evenings, particularly on rocks, or other substrates which have been warmed by the sun (Corbet & Brooks, 2008)[10]. On the other hand strategies which reduce overheating can include: (i) periodically diving into water during flight; (ii) perching at the very tip of a stem or jutting object to reduce the amount of heat reflected from below; (iii) flexing wings forwards and downwards to cover the thorax[11] (Fig. 11a); (iv) assuming the "obelisk" position in hot environments (Fig. 11b) and; (v) choosing to settle in shaded areas of woodland, in caves or on overhanging rocks (Silsby, 2001; Brooks, 2002)[12].

Odonates, particularly anisopterans, are excellent, very fast flyers, with highly developed flight manoeuvring powers, hovering in one place for around a minute, more than which would interfere with homeostatic functions (Askew, 2004). Wings are equipped with a complex range of powerful muscles which enable fore- and hindwings to operate separately hence enable more control in flight (Corbet, 2004; Wooton & Newman, 2010). During forward flight, each wing is moved in a figure-of-eight motion. Odonates typically take to patrolling the skies, particularly in the vicinity of water bodies such as ponds, streams, marshes, rivers, and lakes mostly during daytime. Some species (e.g. some aeshnids) may continue these flying routines even at dusk (Dijkstra & Lewington, 2006).

[10] Some species which occur in colder climates or which emerge early on in the year may have hairs on the thorax which increase insulation and reduce heat loss (Askew, 2004).
[11] It is also argued by some that, in the many (particularly tropical) species having brightly coloured wings, covering the thorax by the wings will shade the thorax from the sun more effectively (Silsby, 2001).
[12] Some species will prefer to hunt at dawn and dusk to prevent overexposure to the sun (Askew, 2004).

Corbet & Brooks (2008) define four categories of non-trivial flight:

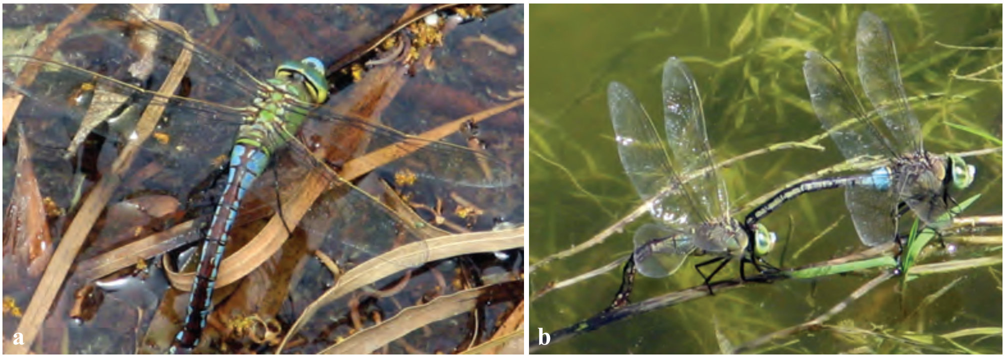
1. *Maiden flight*: A one-way flight from site of emergence to first resting site. This is carried out by tenerals, and usually oriented away from water. The distance of such flights is usually between 1 to at least 500 m.
2. *Commuting flight*: A two-way flight between roosting sites and foraging/reproductive sites.
3. *Seasonal refuge flight*: A two-way flight between emergence site and refuge site that offers opportunities for foraging and maturation to take place in hot dry summers.
4. *Migration*: A one-way flight between emergence site and new reproductive sites. It may be facultative or obligatory and occurs only once per generation. Adults roost at ground level by night, ascend on morning thermals to regain high level winds and descend again in the evenings.

Figures 11a-f: Behavioural strategies in Odonata. **a-b**: Prevention of overheating; **a**: *Orthetrum trinacria* male covering the thorax with the wings; **b**: *Sympetrum fonscolombii* male adopting the obelisk position. **c-d**: Male aggressive behaviour towards rivals; **c**: conspecific in *Ischnura genei*; **d**: heterospecific between *Orthetrum trinacria* (right) and *Crocothemis erythraea* (left); **e**: *Anax parthenope* in the heart position; **f**: *Sympetrum fonscolombii* tandem pair.

Different authors (e.g. Miller, 1995; Silsby, 2001; Brooks, 2002) agree that, because odonates are powerful flyers capable of covering long distances in short times, they can easily colonize new grounds. This can happen when the immediate environment becomes inhospitable (e.g. when available water bodies dry up)[13].

Silsby (2001) defines migration as "*seasonal movement of complete populations of animals to a more favourable environment*", but claims that the term "seasonal" cannot be attributed to odonates. The author classifies odonate migration as being long-distance and short-distance[14]. Long-distance dispersal, one way migration is essential for species that breed in seasonal pools (Brooks, 2002). This type of migration is carried out by some aeshnid and libellulid species that are compulsive migrants, e.g. *Pantala flavescens*, a species which occurs in both the old and new world. Long-distance migrants such as the above-mentioned species are also physiologically adapted to support migration namely by (i) having broad based hindwings that increase the surface area of the wing, for lift, thus enable the insect to glide for up to five hours and drift over the thermals thus conserving energy and (ii) being perfectly adapted to feed on aerial plankton present in the upper atmosphere (Silsby, 2001; Brooks, 2002). It appears that long-distance migrant species, e.g. *Anax ephippiger*, will start migration from the moment they are immature, or even teneral (Corbet, 2004). Moreover, the migration usually involves thousands of specimens. Short-distance migrants will migrate as mature adults in search of new egg laying sites. It is suggested that synchronized emergences, shortage of food, unfavourable conditions (e.g. the arrival of cold fronts) and favourable winds encourage this type of migration. Migrations of temperate species will not involve whole populations, but will involve immature as well as adult specimens (Brooks, 2002).

Long-distance migrants occurring on the Maltese Islands include the above mentioned *Pantala flavescens* and *Anax ephippiger*, with the latter having a very wide distribution range from South Africa to the Mediterranean Region up to Asia. Other locally occurring species with migratory habits include *Aeshna mixta*, a species with an increasing distribution range throughout Europe, and *Sympetrum striolatum.*



Figures 12a-b: Oviposition in aeshnids. **a**: unaccompanied (*Anax imperator*); **b**: in tandem (*A. parthenope*).

[13] Brooks (2002) argues that species, particularly tropical ones, that frequent more permanent water bodies tend to be more sedentary.
[14] Silsby (2001) calls long-distance migration "big time" and short distance migration as "small time".

Adult males establish territories in areas where water is present. Any intruding males are aggressively challenged out of the territory (Figs. 11c & d) while any passing female is encouraged to mate. During copulation, males grasp females by means of the hamules, either from the pronotum at the base of the head (in Zygoptera), or from the head itself (in Anisoptera). The pair will then fly in tandem (Fig. 11f), and eventually copulate by the female connecting her genitalia to the male secondary genitalia in what is known as the heart position (Fig. 11e). Miller (1995) explains that the duration of copulation can be brief e.g. in *Crocothemis erythraea*; medium e.g. in *Sympetrum* and long e.g. in aeshnids and *Ischnura*, where it takes several hours for completion. The male would have meanwhile transferred sperm from the genital opening on the 9th abdominal segment to the 2nd where sperm transfer organs are found. Once the female joins the tip of her abdomen to the 2nd segment, the rapid transfer of sperm from male to female is completed.

Fertilization is controlled by the female during oviposition. Odonate males therefore need to ensure that it is their sperm which is used by the female for such process. In order for this to happen, males are known to attempt to manipulate the sperm of rivals within the reproductive system of females. Such process is known as sperm competition (Miller, 1995). Strategies used by males to increase the chance of their sperm being used to fertilize the eggs of the female may include: (i) guarding females while ovipositing to prevent other males mating with the female (e.g. *Orthetrum coerulescens*); (ii) being able to push rival sperm into the more remote parts of the female storage organs, hence reducing the chances of rival male sperm to be used in fertilizing the eggs and; (iii) having a penis which is capable of removing rival sperm before depositing own sperm (Miller, 1995; Dijkstra & Lewington, 2006). Moreover, in some species (e.g. *Orthetrum cancellatum*) the sperm storage organs are very small, with very narrow spermathecae, or ducts, which may enable males that perform longer copulations (generally non territorial males) to successfully flush and replace sperm from previous matings. In these species, males often engage in behaviour routines to induce females to oviposit right after copulation (Corbet & Brooks, 2008).

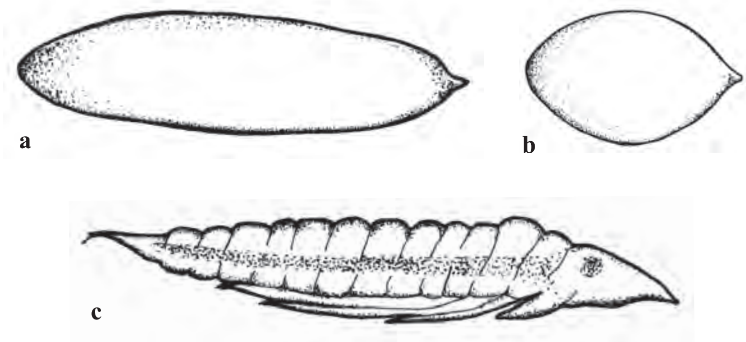
In other species (e.g. *Crocothemis erythraea*) the sperm storage sac in the female is shaped so that mixing of sperm cells from previous matings is reduced, hence increasing the probability of sperm cells from the last mating to be the ones used by the female to fertilize the eggs (Miller, 1995).

In some species, the pair can disengage after copulation and go their separate ways, with the female then ovipositing alone unguarded by the male (Fig. 12a). In others, males will guard females while ovipositing. Two guarding strategies are identified by Miller (1995) and Corbet & Brooks (2008): (i) contact guarding, where males remain in tandem with females during the oviposition period (Fig. 12b) and (ii) non-contact guarding, where the tandem pair will disengage prior to oviposition, but the male will keep guarding the female from a distance (e.g. *Orthetrum coerulescens*)[15].

[15] The females of many species which use male guarding strategies have however been also reported to oviposit alone and unguarded (e.g. *Crocothemis erythraea*).

Life cycle and pre-imaginal stages

Odonates are hemimetabolous[16], undergoing three stages in the life cycle which include the egg, the larva[17] and the adult (or imago). The adult female lays eggs inside floating vegetation[18] or directly into water. Eggs which are laid endophytically tend to be longish and cylindrical in shape (Fig. 13a). Those oviposited exophytically may be more globular, almost spherical in shape (Fig. 13b). From these, a prolarva (Fig. 13c) will hatch. This larval form is distinctly different from the other larval stages. It cannot walk, eat or swim. The prolarva generally moults within a very short time span to turn into what Corbet & Brooks (2008) refer to as the "cryptically coloured stadium 2 (or F2)" larva. This will in turn undergo a series of moults in a process called ecdysis. Figures 14 and 15 represent a typical damselfly and dragonfly larva respectively, with the most important morphological features (many of which are diagnostic for species identification) labelled.



Figures 13a-c: eggs and prolarvae. **a**: endophytic type egg (*Anax imperator*); **b**: exophytic type egg (*Sympetrum striolatum*); **c**: prolarva (*Anax imperator*).

The final instar eventually climbs out of the water, leaving its aquatic habitat, and moults, leaving behind an empty skin or exuvia (Fig. 16). Periodical measurements of body length of odonate larvae reared by the author revealed that temperature affects growth rate (Degabriele, 1992). This matches claims by other authors (e.g. Uzteri, 1987).

After the final moult, larvae develop into tenerals[19] (Fig. 17). During this phase, the insect has no or very pale pigmentation, a pale pterostigma, and very shiny wings. The cuticle hardens within a few hours, after which the insect is capable of flying. Adult pigmentation takes a few days to develop, by which time the specimens would also become sexually mature. Specimens that are not sexually mature may stay away from aquatic habitats in search of prey. In a number of species, specimens develop a powdery blue deposit over part or all of their body (e.g. *Orthetrum*, *Trithemis annulata*), known as pruinosity (pruinescence). This occurs mostly in males, but may also be found in older females. Since pruinosity develops as the specimen becomes mature, sexually immature males may have body coloration which is similar to females. They are usually recognized by the presence of secondary sexual genitalia and by the narrower abdomen.

[16] Odonates belong to the Superorder Exopterigota, where vestigial wings start to show during the last larval stages before developing into an adult.
[17] Corbet (2004) and Corbet & Brooks (2008) argue that it is more appropriate to refer to developmental stages between the egg and the adult as the larva rather than nymphs or naiads. The term "larva/e" will also be used in this work to refer to individuals in these phases in the life cycle.
[18] Occasionally some species may lay eggs on top of vegetation and are termed *epiphytic* (Corbet & Brooks, 2008).
[19] A feature which odonates share with ephemeropterans (mayflies).

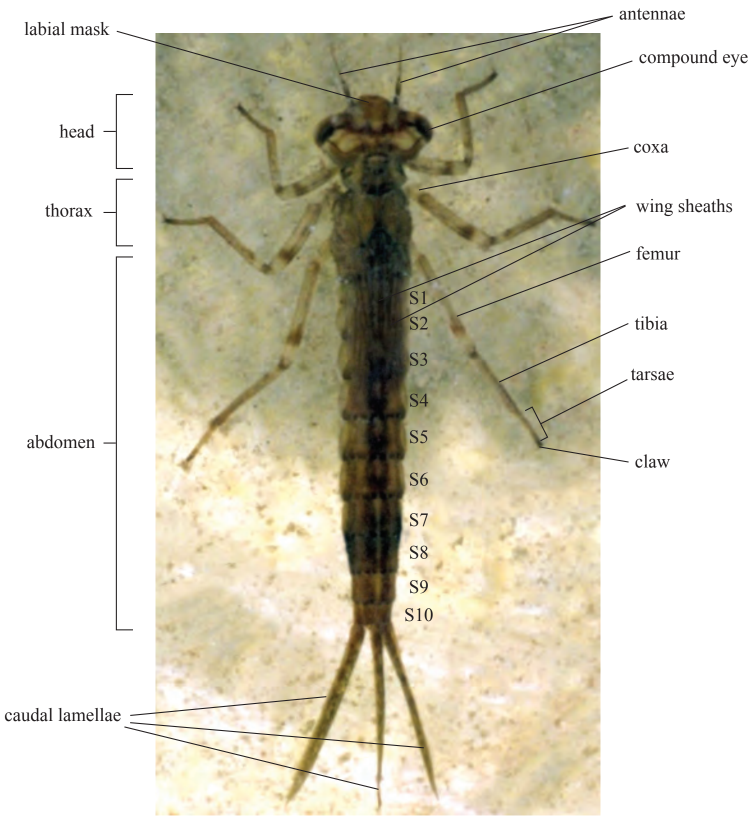


Figure 14: Main morphological features of a zygopteran larva (*Ischnura genei*).

The great majority of odonate larvae, are aquatic, mostly living in freshwater[20]. Many species breeding on the Maltese Islands have larvae which can tolerate brackish waters, possibly due to the lack of available freshwater bodies on the islands. A number of larvae and exuviae of different species (namely *Ischnura genei*, *Anax* and *Sympetrum*) were in fact recorded by the author in brackish water such as at il-Magħluq in Marsascala, and is-Simar in Xemxija.

Odonate larvae have developed a system of gaseous exchange to be used in aquatic conditions. Zygopterans have developed three leaf-like caudal appendages[21] or lamellae (Fig.18) which are rich in tracheal tubes in order to maximize the efficiency of gaseous exchange. These lamellae also serve as swimming appendages (Abbott, 2005; Corbet & Brooks, 2008), and can easily detach if the larva is attacked by a predator. Larvae can still survive with these missing appendages. Anisopterans have developed elaborately patterned, richly tracheated gills which are arranged in tufts inside the wall of the rectum. Abdominal pulsation movements force water in and out of this region by means of a muscular diaphragm. This structure can also be used to expel water at high pressure from the abdomen, enabling larvae to swim at high speeds by jet propulsion, and providing a quick means of escape for the larvae from predator attacks - they have been observed by the author to shoot a jet of water rectally if lifted out of the water.

[20] In some species, particularly tropical ones, larvae can live amongst damp leaf litter (Silsby, 2001; Askew, 2004).
[21] Though in a few tropical species, the upper one can be somewhat reduced.

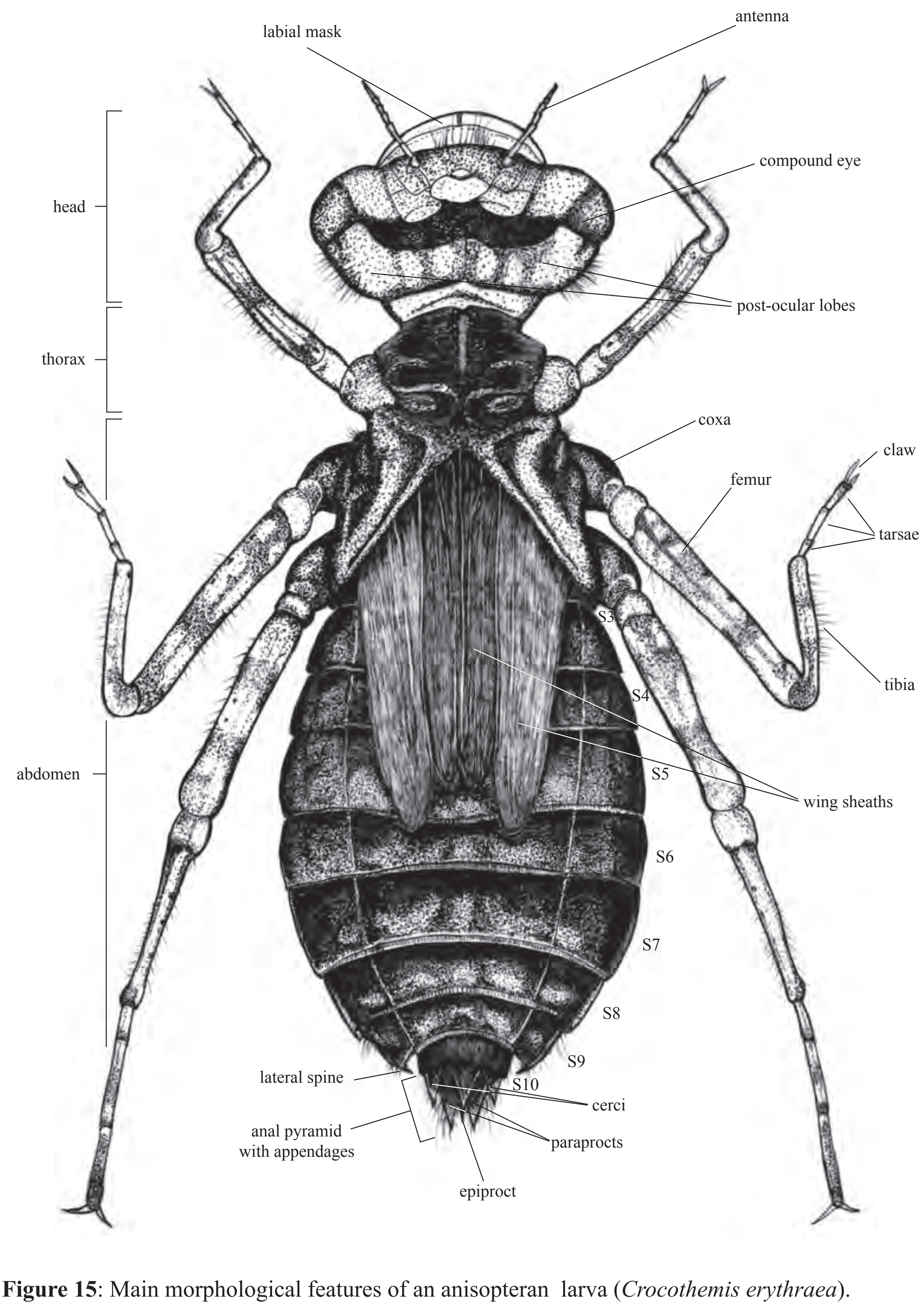


Figure 15: Main morphological features of an anisopteran larva (*Crocothemis erythraea*).

Like the adults, larvae are also predatory. The fact that larvae live in aquatic habitats helps to reduce competition for resources with adults. Larval diet can consist of a variety of organisms ranging from protists (which make up the staple diet of the first and second instar larval stages) to larger organisms such as water fleas (*Daphnia*), small snails, mosquito larvae and even tadpoles and small fish. They may also be cannibalistic on specimens of both the same and different species which are at considerably earlier stages of development. This is more likely to happen if larval population density is high (Corbet & Brooks, 2008). Odonate larvae possess a labial or facial mask (Fig. 19) a modification of the labium, which is fired at prey and retracted bringing food to the mouth. The mask is equipped with serrated structures that grip and chew the prey. Observations of larval feeding patterns by the author, as well as by Corbet (2004) have revealed that larvae preferred to feed largely on the most common available organism which is suitable as prey at one particular moment, and that this preference changes according to prey availability. In general, prey numbers are never reduced to create ecological unbalances (Corbet, 2004). Moreover, in cases observed by Corbet (2004) where dragonfly larvae were feeding on fish fry grown in fish farms, the number of specimens eaten never reached numbers high enough to meet economic thresholds, unless the larvae were confined with the prey in very small spaces.

In terms of behaviour, Corbet & Brooks (2008) classify larvae into four main types:

Claspers: Those having large symmetrical compound eyes, long, smooth, streamlined bodies and a symmetrical abdomen. They are active and constantly look for prey. They cling to pond vegetation near the water surface. e.g. *Anax imperator*;

Sprawlers: Those having small, less symmetrical compound eyes and a squat abdomen. They are active and constantly look and feel for prey. They stay in or near pond vegetation near the water surface. e.g. *Crocothemis erythraea* (Fig. 20a).

Hiders: Those having small asymmetrical compound eyes and a squat setose abdomen. They are slow moving and constantly feel for prey. They inhabit fine detritus or coarse leaf litter (Fig. 20b). e.g. *Orthetrum cancellatum.*

Burrowers: Those having small asymmetrical compound eyes and a elongate setose abdomen. They are slow moving and constantly feel for prey. They live amongst fine stones, sand or gravel where the stout hind legs are used to dig shallow tunnels (e.g. *Orthetrum coerulescens*[22]) or deep ones. They stay in burrows that they dig in the silt of the bed ambushing prey from their hiding place.

The larvae of some species (e.g. *Ischnura*, *Anax*, *Sympetrum* and *Crocothemis*) show territorial behaviour defending feeding territories from other larvae (Corbet, 2004). Differences between zygopteran and anisopteran larvae are summarised in table 13 (pg.105).

Observing odonates

When observing odonates in the field, one can get a lot of information about their habitat preferences as well as their flight and behavioural patterns. Local research (e.g. Balzan, 2012) has shown that habitat-odonate relationships are important implications for dragonfly monitoring.

[22] Larvae of this species sometimes also behave as hiders.

Sites which are suitable for observing adult odonates on the Maltese Islands include fresh or brackish aquatic habitats, particularly if the areas are sunny and sheltered, and include a variety of aquatic and waterside vegetation. Natural habitats include valleys, natural streams and ponds and brackish water estuaries, while man-made habitats include open water reservoirs and garden ponds. Being fast fliers, odonates usually come close enough to be observed, although some species e.g. *Selysiothemis nigra* can be quite skittish and may be tricky to photograph. Special habitats e.g. stretches of open countryside can also yield a number of immature individuals foraging for food. In the early mornings, one may encounter some aeshid specimens already on the wing. During evenings, some of these aeshnids are still active, and one can come across roosting sites particularly for libellulids. Grassy areas with a lot of plants that serve as perches are typical sites to observe some species (e.g. *Sympetrum*) when roosting in groups in the evening. With time one gets used to where dragonflies might be during different times of the day.

Some authors (e.g. Miller, 1995) suggest documenting data from observations by compiling tables of records of specimens of different species observed in different habitats during different times of day and different seasons. Materials required during field trips include a notebook (or clipboard) with a pen, ideally attached with string, a pair of close focus binoculars, a pocket hand lens and good fieldwork guide (Fig. 21). A good camera is also a must. Waders, or at least a good pair of wellington boots, can prove useful if wanting to observe dragonfly behaviour around water bodies.

Capturing and collecting specimens

There are different views regarding whether to collect specimens. Whilst photography is a good way of recording specimens, Corbet & Brooks (2008) argue that it is important to keep voucher specimens for further reference particularly if for example the species is hard to photograph, or if one is studying anatomical features (e.g. secondary genitalia in males) where photographs of specimens taken in the field may offer little help.

Corbet & Brooks (2008) also point out however that a code of practice has been promulgated by the Worldwide Dragonfly Association (WDA) through which a number of conditions need to be followed when collecting odonate specimens. Such conditions include: (i) collecting adult and larval specimens only in the interests of scientific research; (ii) respecting collecting laws of the country of origin of the concerned specimens; (iii) obtaining collection permissions from the necessary authorities where necessary; (iv) providing a list of collected specimens to the concerned authorities and (v) properly annotating and preserving the material collected.

Whether capturing odonates for inspection, or for conducting capture/recapture investigations, or for collecting, the insects can be captured using an entomological net (diam. 40-75 cm, Keen, 1977; Dijkstra & Lewington, 2006) with fine mesh and long handle (1-2 m long, Dijkstra & Lewington, 2006). Specimens are killed and preserved by immersing in acetone[23] for a number of hours (Dijkstra & Lewington, 2006[24]; Minnesota Odonata Survey Project, n.d.), as this will dissolve the fat in the body of the insect and preserve the internal pigmentation, which will otherwise turn black, particularly if remains of food are found in the gut of the animal. Once preparation is over, specimens are not set with wings open as in Lepidoptera (butterflies and moths), but rather they are placed in a polythene or polypropene envelopes[25], along with a card bearing the record data. These

[23] One needs to use caution when handling acetone as this is highly flammable.

[24] Dijkstra & Lewington, (2006) suggest leaving the specimens immersed in acetone for up to 24 hours.

[25] Polythene envelopes are less sturdy. Polypropene tends to accumulate static electricity and specimens may stick to the envelope, making it difficult to remove the specimen for examination at a later date without breaking it.

Figure 16: Exuvia of *Anax parthenope.*

Figure 17: Freshly emerged (teneral) *Crocothemis erythraea.*

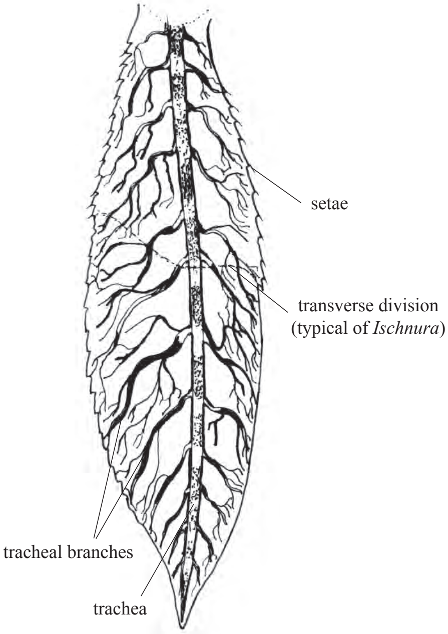


Figure 18: Caudal lamella (*Ischnura*).

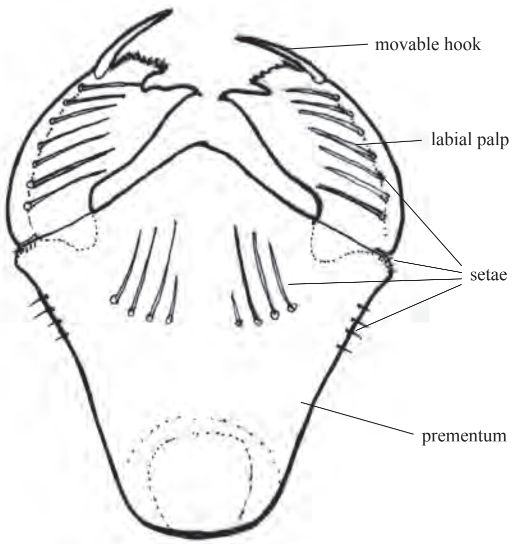
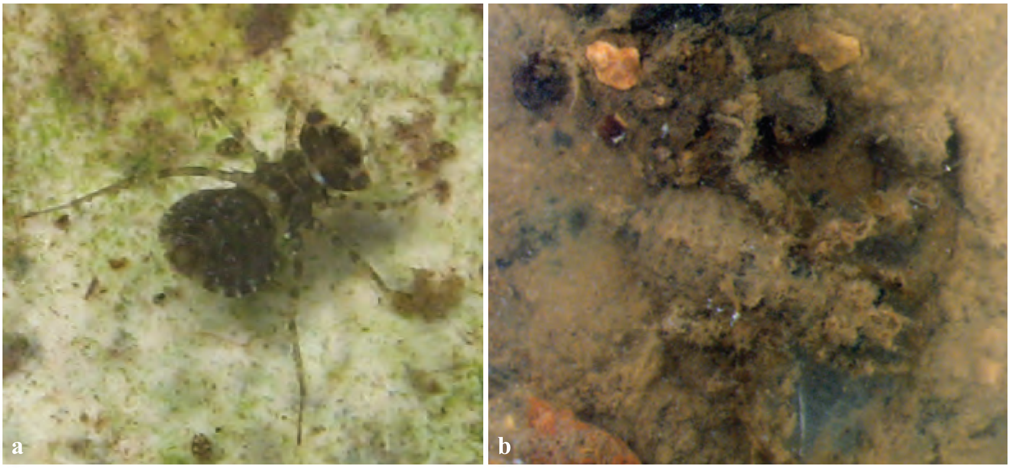


Figure 19: Larval labial mask (*Ischnura genei*).



Figures 20a-b: Larval habits. **a**: sprawler (*Crocothemis erythraea*); **b**: burrower (*Orthetrum*).

cards can be cut to a fixed size and specimens can then be stored for future reference. Keen (1977), Miller (1995) and Dijkstra & Lewington (2006) all suggest that exuviae can also/alternatively be collected if one wants to study the species which inhabit a specific water body. If cleaned and dried, exuviae will conserve well.

Figure 21: Equipment required for fieldwork.

Odonate larvae can be captured using a dredging net having a mesh of 1x1 mm (Cham 2007, 2009), stretched over a triangular frame so the net can be dragged along the bottom of some water bodies. The mesh has to be small enough to trap odonate larvae. If reared in captivity, odonate larvae need to be kept separate from each other as they can eat each other if kept in containers which are too small, or if larvae are kept in overcrowded conditions.

Cham (2007, 2009) suggests that breeding should take place in conditions which are very close to those found outdoors. If for example larvae are grown indoors where ambient temperature may be considerably higher in winter, the life cycle duration will be reduced. Adults may therefore emerge at times which are not ideal due to the outdoor climatic conditions being too inhospitable for the specimens to survive.

It is important to have access to suitable guidebooks and reference material. Relatively little has been written on Odonata as compared to material written on some other insect Orders (e.g. Lepidoptera). The following is a list of general or comprehensive books on Odonata that can be relevant to such a purpose:

Askew R.R. 2004 *The dragonflies of Europe* (revised edition). Harley Books Colchester, UK. 308 pp. - A revised edition of a 1988 classic monograph of European Odonata.

Corbet P.H. & Brooks S. 2008 *Dragonflies.* New Naturalist 106, Harper Collins, London, UK. 454 pp. - A comprehensive book for the advanced reader, which gives information on the biology and ecology of dragonflies with special focus on the British species.

Cham S. 2010 *Field guide to the larvae and exuviae of British dragonflies*. British Dragonfly Society Peterborough, UK. 152 pp. - A photographic guide of the exuviae and larvae of British Odonata, previously available in two volumes.

Dijkstra K.D. & Lewington R. 2006 *Field guide to the dragonflies of Britain and Europe*. British Wildlife Publishing, Dorset, UK. 320 pp. - One of the most complete guides to the European and North African species to-date.

Silsby J. 2001 *Dragonflies of the World.* The Natural History Museum, London, UK. 224 pp. - The only book of its kind ever written, it gives a beginners guide to Odonata and a family by family comparison of world Odonata.

The Maltese Islands

The Maltese Islands (Fig. 22) are found in the centre of the Mediterranean basin, 93 km south of Sicily, 352 km north of Tripoli, 288 km east of Tunis. The archipelago is 45 km in length, cover an area of 361 km^2 (Pedley *et al*., 2002) and consists of a number of islands.

Figure 22: Map of the Maltese Islands.

Malta, situated in the southernmost region, is the largest island in the archipelago. The island is 28.3 km long and 14.5 km wide, with an area of 196.8 km^2 and highest point being above near Ta' Dmejrek, close to Dingli village, at 253 m above sea level. The second smaller island, the northernmost island of Gozo, is 14.5 km long and 7.2 km wide, and has an area of 67.07 km^2 and highest point at Ta' Dbiegi at 191 m above sea level. This island is greener and relatively less developed, and hence still has larger stretches of countryside which are left untouched by humans. A smaller island, that of Comino, is found in the strait between Malta and Gozo. It is 2.6 km long and 2.25 km wide, has an area of only 2.78 km^2 and highest point is only 75 m above sea level. This island is the least developed - being almost uninhabited. It consists mostly of bare land with very little available fresh water (Azzopardi, 2002).

A number of smaller uninhabited islets also exist, namely Selmunett (off the coast of Comino) and Filfla (to the south of Malta off the coast of Wied iż-Żurrieq). The latter island has progressively become smaller in recent years, partly because it was formerly used for military target practice from the 1940's to the 1970's and also because of progressive erosion. It is now declared a natural sanctuary and access is restricted to only those wanting to research the fauna and flora inhabiting the islet. Because of the size and origin of the Maltese Islands, the variety of habitats within the islands is rather limited. There are no mountainous ranges, large forests, and rivers or lakes. Consequently, the species diversity of many insects, including Odonata, is limited as compared to the number of species found on the continent. Moreover, the fact that the islands are relatively isolated also contributes to the limited species diversity of dragonflies.

The climate of the islands alternates between mild rainy cold seasons and dry hot seasons (Chetcuti *et al.*, 1992) from early June to the end of September, with temperatures during this season sometimes peaking at 40°C, although the average for the whole season is about 30°C. The freshwater ecology depends exclusively on the relatively short rainy season, with rainwater being the only natural water source available to the islands. Water availability on the islands is rather scarce. Typical average rainfall for the period 1900-2000 was of 550 mm for the period[26] (FAO, 2006). Moreover, there is a high demand for water resources. Abstraction of groundwater, necessary to sustain the relatively limited perennial surface water ecosystems, exceeds aquifer recharge rate (FAO, 2006). Agricultural water demand, used to irrigate 29% of the total utilized agricultural area (NSO, 2010), is also projected to increase, and is significantly higher during the summer months (FAO, 2006). This limits the availability of freshwater habitats and hence the biodiversity of aquatic organisms inhabiting the Maltese Islands. The freshwater fauna and flora has adapted to manage the active part of their life cycle during the wet season.

The predominant habitat is karstland, which forms when groundwater containing dissolved carbon dioxide percolates through the rocks, and gradually dissolves the calcium carbonate, leaving insoluble residues of iron oxides in cavities. This process leads to the formation of soil patches, which are subsequently colonised by vegetation. Rainwater pools in the karst are also frequent. These are typically inhabited by organisms that have a very short life cycle, and which can lay eggs that resist dry conditions, e.g. Anostraca (fairy shrimps). Dragonfly larvae are not commonly found in these habitats (Lanfranco, 1990), although immature adult individuals can frequent the karst in search of prey.

Valleys found in the western and north-western parts of Malta and throughout the coastal areas of Gozo contain the most diverse freshwater fauna and flora. This part of the islands is where rainwater accumulates most, due to the occurrence of Blue Clay, a soft rock with very fine pores, and higher

[26] although this period had a high seasonal and inter-annual variability.

water retention properties than any other forms of rock locally. Freshwater streams form whenever there is an exposed ridge between the Blue Clay layer and the porous rock layers above it. In most cases however, these valleys are mostly dry-they only contain water following bouts of heavy rainfall most of which flows to the sea within a short period of time.

Habitats frequented by Odonata

Odonates face problems of lack of aquatic habitat and have to adapt behaviourally and physiologically (Degabriele, 1992). According to Balzan (2012), most local odonate species are strongly associated with lentic habitats (i.e. habitats which contain standing water), with some such as *Orthetrum trinacria* and *Selysiothemis nigra* being found exclusively in these habitats (Balzan 2012). The work by Balzan also showed that although other local species were still strongly associated with lentic habitats, they were also to be found in lotic environments (moving water bodies), implying a tendency for being euryoecious (able to frequent broad variety of ecological living conditions regarding a single factor, in this case lentic and lotic water bodies)[27]. This tendency for adaptability could probably be the reason why all species inhabiting the Maltese Islands, with the exception of *Orthetrum nitidinerve,* are given a "Least Concern" status in the "European Red List of Dragonflies" (Kalkman *et al.*, 2010).

The most common type of freshwater habitats on the islands are lentic water bodies. They include:

Valley courses: These are habitats where water runs from valley sources till it reaches the coast at the valley mouths. In a number of these habitats, e.g. the valley complex of Għajn Riħana (particularly Wied tal-Imselliet, Wied il-Ħżejjen (Fig. 23a), and Wied Riħana), il-Fiddien which feeds into Wied il-Qlejgħa limits of Rabat (also popularly known as Chadwick Lakes), and Wied Ħesri in Siġġiewi (Fig. 23b), shallow dams were built that slow the water so that it can be used for irrigation purposes. This makes the habitat suitable for species that like slow moving to stagnant waters, e.g. *Anax imperator* and *Crocothemis erythraea*. Although these valleys are frequented by a number of species, not all valley water courses are used as breeding grounds. Very few larvae and exuviae were found at Baħrija and Qlejgħa valleys by the author (Degabriele, 1992). Balzan (2012) found no larval odonata recorded along Baħrija, Qlejgħa, Ħesri and Lunzjata valleys. On the other hand, recent scouting at Qlejgħa valley by the author during late September 2012 yielded a small number of exuviae of *Anax* and *Crocothemis erythraea* while a number of species were observed to oviposit in the area. This may imply that the occurrence of odonates in these locations is sporadic and dependent on water availability in the site, which is in turn dependent on the degree of human disturbance (e.g. draining of water from the valleys for irrigation purposes).

Rainwater pools: These can be either situated in valley areas with no connection to the sea, particularly if artificial dams are constructed for irrigation purposes. Examples of such type of pools are those which form at Wied Ħesri, Siġġiewi, They can also be occasionally found away from valley areas, such as the rock pools at Mrieħel, B'Kara, Malta (Fig. 23c). The majority of these pools dry up rather quickly, although this depends on the amount of rainfall during the winter season. Because the water dries up, these habitats may not allow the larvae to complete the life cycle. However, some species may still successfully breed in such sites, possibly as they might speed up their life cycle due to a warmer climate. Exuviae of *A. imperator*, a species known to have a life cycle with a duration of usually around one year in mainland Europe, were found by the author

[27] This contrasts with other works concerned with the influence of habitat characteristics on Odonata assemblages, which have identified particular dragonfly associations to specific habitat types (Clark & Samways,1996; Samways, 1996; Schindler *et al.*, 2003; all in Balzan, 2012).

Figures 23a-d: Habitats typically frequented by Odonata in Malta. **a**: Valley course (Wied il-Ħżejjen, Żebbiegħ); **b**: Rainwater pool in a valley area (Wied Ħesri, Siġġiewi); **c**: Rainwater pool away from valley area (Mrieħel, B'Kara); **d**: Brackish water pool (Simar Nature Reserve, Xemxija).

Figures 24a-d: Important landmarks in Gozo typically frequented by Odonata. **a**: Għadira tan-Nadur; **b**: Sarraflu, Kerċem; **c**: Għajnsielem; **d**: Qattara, Dwejra.

during the early 1990's in Wied Għollieqa, San Ġwann, Malta, an area where a rainwater pool used to form in winter and dry up completely in summer. Pools which do not dry up in summer are more commonly found in Gozo. Examples include the ones at Nadur, at Sarraflu, Kerċem (which has been artificially enlarged), and at Għajnsielem (Figs. 24a-c). Such habitats tend to be frequented by stagnant water loving species such as *Ischnura genei*, *Crocothemis erythraea*, *Anax imperator* and *A. parthenope*.

Brackish water pools: These form where inland freshwater comes in contact with seawater, or where confined bodies of seawater are diluted by rain during the wet season. They include naturally formed, or in some cases reclaimed salt marshes, e.g. Għadira and Simar Nature Reserves (Fig. 23d), as well as man-made open water reservoirs e.g. Il-Magħluq at M'Scala, and Il-Ballut in the area known as Il-Magħluq at M'Xlokk, Malta. Because of the scarcity of freshwater habitats, a number of local species are known to breed in brackish water (Miller, 1995; Askew, 2004). Indeed those species that have not adapted to oviposit in brackish water (e.g. some *Orthetrum* species) are generally less common and more localised.

A number of species have been observed to oviposit in brackish water. Odonate larvae and exuviae were also collected by the author from il-Magħluq at M'Scala, and il-Ballut, at M'Xlokk, (Degabriele, 1992). However in the more recent work by Balzan, no larvae or exuviae were found at il-Ballut, M'Xlokk, and Ramla l-Ħamra, Gozo (Balzan, 2012). Possible reasons for such conflicting results could be the different levels of dilution of the saltwater by rain in the different sites at different times of the year. It may be that the species which inhabit the sites visited by the author may complete the life cycle before salinity rises during the hot season. More research is needed to shed light on this issue.

Man-made ponds, and open water reservoirs: Many ponds found in private and public gardens all over the islands encourage the breeding of odonates. Open water reservoirs commonly built by farmers for irrigation purposes provide a more permanent water source than those which form naturally. However alien species of fauna and flora present (e.g. predatory fish, discussed in the section entitled "Human impact on odonates" on pg.115) may affect odonate populations attempting to breed in such sites. Moreover, the small surface area and absence of macrophytes (aquatic vegetation) in such reservoirs tends to reduce the number of species frequenting these sites (Balzan, 2012). Such sites are mostly frequened by *Anax imperator*, *Crocothemis erythraea* and *Ischnura genei*, with the latter being present if any form of aquatic vegetation is present in the site.

Lotic water habitats, which include freshwater streams, were more common in the past, and as they have become progressively scarcer, so have the aquatic organisms that depended on such habitats (Schembri, 1991). These habitats also tend to dry up more quickly in summer. Examples include the freshwater streams at Fiddien and at Wied il-Luq in Buskett (Fig. 25a). Organisms that live in streams and moving water are few and uncommon. *Orthetrum brunneum* is an example of such type of species. It has been recorded only from a few inland locations, such as at Rabat (Fig. 25b).

The terrestrial landscape is as important for odonates as aquatic habitats. Such landscapes frequented by odonates include:

Valley mouths: These directly face the coast e.g. Wied Babu, Żurrieq, Malta (Fig. 25c), and Il-Qattara, Dwejra, Gozo (Fig. 24d). They are often a "first port of call" for migratory species like *Anax parthenope*, *A. ephippiger* and *Crocothemis erythraea*.

Open grassy areas: These are often, though not always, found in the vicinity of water e.g. Qlejgħa valley (Fig. 25d). Most species prefer sunny spots although some *Orthetrum* species prefer to perch in shady areas close to water bodies (Degabriele, 1992). Areas found away from water can also abound in immature specimens hunting for prey before reaching sexual maturity. They can be also used by some species (e.g. *Sympetrum*) as roosting sites particularly if plants which provide suitable perches (e.g. fennel, *Foeniculum vulgare*) grow in the area.

Relationships of Odonata with other species

Dragonflies and damselflies are voracious predators, and thus occupy a rather high position in the trophic hierarchy. Adults feed on a variety of animals such as smaller insects (e.g. Diptera, Hymenoptera and Lepidoptera). Some species also feed on other odonates, usually on species which are smaller such as *Anax* on *Sympetrum* (Fig. 26a). The larval diet (as discussed on pg.24) consists of pond organisms such as protists, small crustaceans (e.g. *Daphnia*) mosquito and mayfly larvae, and tadpoles.

Odonate larvae and adults are in turn preyed upon by larger carnivores. Various authors (e.g. d'Aguilar *et al*., 1986; Askew, 2004; Corbet & Brooks, 2008) list fish, amphibians, and arthropods (e.g. spiders, robber flies, wasps, and other odonates) as typical adult odonate predators. Large diving beetles have been observed by the author to capture smaller odonate larvae. Local predators of odonate adults, also observed by the author include other larger odonates (Aeshnidae), spiders for example *Argiope lobata* and *A. trifasciata* (Fig. 26b), mantids such as *Mantis religiosa* (Fig. 26c), and the chameleon, *Chamaleo chameleon* (Fig. 26d).

Askew (2004) describes birds as the main predators of odonates. d'Aguilar *et al*. (1986) and Corbet & Brooks (2008) list a number of birds which typically prey on odonates. Local observations of birds capturing and consuming odonates (mostly in flight) include bee eaters (*Merops apiaster* - Fig. 26f) and hobbies (*Falco subbuteo*), lesser kestrels (*Falco naumanni*), red-footed falcons (*Falco vespertinus*) and Eleonora's falcons (*Falco eleonorae*) (Fenech, N. *pers. comm.*).

Corbet & Brooks (2008) also mention that bats use echolocation to capture odonates, while roosting at night. The mouse-eared bat (*Myotis punicus*) has been locally observed to hunt for odonates (Sciberras, A. *pers comm.*).

In order to escape predation, odonates adopt a number of strategies. Askew (2004) and Corbet & Brooks (2008) describe how adult odonates use their coloration as camouflage to reduce predation risk. The authors also mention that when captured, odonates may move the abdomen in a threatening posture as to ward off potential predators, try to bite potential predators if given the chance, and if they manage to escape they will either feign death by staying immobile on the ground, or fly rapidly away from the area of capture and not return to the same spot for a period of an hour or so. Zygopterans perching on stems sometimes try to slip around the stem away from the predator.

Odonates also act as a host to a number of parasites. d'Aguilar *et al*. (1986), Askew (2004) and Corbet & Brooks (2008) describe gregarine protozoan parasites, which usually exclusively parasitize invertebrates, to be found in the abdominal region of odonate larvae. Askew (2004) claims that gregarine protozoa damage the mid gut epithelium of larvae and make it prone to bacterial infection, however Corbet & Brooks (2008) argue that assessing whether the viability of individual is reduced by gregarine protists is difficult to establish. Other odonate endoparasites include parasitoid hymenopterans. These can infect odonate eggs which are laid endophytically.

Figures 25a-d: Habitats typically frequented by Odonata. **a**: Freshwater streams (rural) (Wied il-Luq, Buskett); **b**: Freshwater streams (urban) (Rabat); **c**: Valley mouths (Wied Babu); **d**: Open grassy areas in proximity of valleys (Wied il-Qlejgħa).

The parasitoid egg, laid within the odonate host egg, will hatch quickly and feed on the egg contents thus killing the developing larva inside. Parasitic species belong to two Hymenoptera groups: Chalchidoidea and Sceliinidea (Corbet & Brooks, 2008). These species parasitize only endophytic Odonata (Corbet, 1962).

Askew (2004) and Corbet & Brooks (2008) also explain that odonates also tend to serve as intermediate hosts to a number of endoparasitic platyhelminthes (Trematoda and Cestoda). In most of these cases, the primary host of these worms would be an odonate predator which, while hunting and consuming an infected odonate larva or adult, will also ingest the larval form of the parasite, which will develop into an adult within the body of the primary host.

Some forms of minute flies (Diptera: Cecidomyiidae and Drosophiliidae) develop with the odonate egg mass and feed on eggs (d'Aguilar *et al*., 1986).

The ectoparasites which infect odonates tend to pierce specific regions of the body, namely major wing veins and the thoracic region, and feed on the haemolymph of the host. Examples of such ectoparasites include freshwater mites of the genus *Arrhenurus*. Adult mites wait for the adult odonate to approach the water prior to oviposition and also lay eggs in the water. These hatch into six-legged larvae which settle on a final stadium larva. During the final moult of the odonate the parasite larvae quickly transfer themselves towards the wing base and pierce the cuticle before this hardens in order to suck haemolymph (Corbet & Brooks, 2008). These mites destroy the odonate epidermis at feeding sites. Moreover, heavy infestations weaken the host (Askew, 2004). Species which are particularly susceptible to mite attack include odonates of the genus *Ischnura*, *Aeshna* and *Sympetrum (*Askew, 2004; Kulijer *et al*., 2012). Mites have been locally observed on the thorax of *Ischnura genei* (Fig. 26e), but their identification is still in progress. Other ectoparasites include

Figures 26a-f: Odonate predators and parasites. **a**: *Anax parthenope* feeding on *Sympetrum fonscolombii*; **b**: *Argiope trifasciata* feeding on *Crocothemis erythraea*; **c**: *Mantis religiosa* feeding on *Sympetrum fonscolombii*; **d**: *Chamaleo chamaleon* feeding on *Anax imperator*; **e**: *Ischnura genei* male with mites attached to its thorax; **f**: *Merops apiaster* feeding on *Anax parthenope*.

flies of the family Ceratopogonidae (such as *Forcipomyia paludis*) which also pierce the wing sheaths and thoracic regions of odonates such as *Ischnura*, *Aeshna*, *Sympetrum*, *Crocothemis* and *Orthetrum*, to feed on haemolymph (Martens *et al.*, 2007; Wildermuth, 2012).

Corbet & Brooks (2008) also mention commensals of odonates. Minute miliciid flies of the genus *Desmometopoa* which inhabit the odonate's body and, following a feeding spree of the odonate, glean the debris of prey from the mouthparts of the odonate.

To date, no studies on the parasitoids, parasites and commensals of odonates have been carried out in the Maltese Islands.

Climatic changes in Europe - the effect on the Maltese Islands

Odonate records in the Mediterranean Region during the last ten years (e.g. Dijkstra & Lewington, 2006) show that a number of thermophilous odonate species, many being native of Africa and the Middle East, are extending their distribution northwards towards Europe. Examples of such species include *Crothemis erythraea* (Gonseth & Monnerat, 2003), *Sympetrum fonscolombii* (Lempert,1997), and *Orthetrum brunneum* (Bernard & Invinskis, 2004). Wiligalla & Fartman (2012) who conducted a study on the diversity of species in European big cities, claim that the temporal effect on species richness is likely to be a consequence of the recent increase in Mediterranean species associated with global warming.

Some (e.g. Ott, 2001) attribute this change in distribution to climate change. Recent climatic changes in Europe and the Mediterranean Region are resulting in a climate which is warmer and drier. Since water resources are the key issue for the survival of odonates generally, odonate communities in the Mediterranean basin are threatened with habitat loss (Riservato *et al.*, 2009). Despite the necessity of an aquatic environment in order for the larval stages to develop, some odonates prefer hot climates as adults. This could have led to some form of adaptation of the larvae to be able to survive hotter and drier climates, perhaps by completing the larval stages in a shorter time before the little water available dries up. Moreover, odonates do not have distribution restrictions related to food availability, such as a host plant with limited distribution, as both adults and larvae are carnivorous and will adapt to whatever insect prey is available. This shift in distribution range of thermophilous odonate species has triggered off research such as that by Termaat *et al.*, Parr and De Kniff *et al.* (all in Ott, 2010) where the changing distribution of dragonflies was actually used as an indicator of climatic changes. No such studies have been carried out on the Maltese Islands, however new local records, such as *Trithemis annulata*, *Orthetrum trinacria*, *O. nitidinerve* and *O. chrysostigma* indicate similar odonate behavioural trends. The only possible difference is that while in Europe, some species which prefer habitats which are colder and with more available water may be on the decline[28], most local species can tolerate dry warm weather and therefore the populations of most of these species may not be affected by such a phenomenon. Thus the biodiversity of odonates on the Maltese Islands may well be on the increase and other vagrant species are to be certainly expected in the near future. A list of possible vagrant records for Malta is found towards the end of the present work (pp. 97 - 100).

[28] According to Termaat *et al*. (in Ott, 2010), the decline of these species may also be attributed to other factors such as the degrading quality of the environment.

Previous Literature on Odonates of the Maltese Islands

Relatively little research has been carried out on the odonates of the Maltese Islands, and most of the work consists of lists of species taken from 1899 to the current day.

Next to nothing is known about species occurrences prior to the 1940's, since so very little work has been done concerning local Odonata during this period. McLachan was in fact the first and only author to mention Maltese Odonata in published work (McLachan, 1899). He refers to three common species inhabiting the islands, these being *Ischnura genei*, *Crocothemis erythraea*, and *Sympetrum striolatum*. These species were also mentioned by Cowley (1940). Two papers were subsequently written by Valletta (1949, 1957) on the odonates inhabiting the Maltese Islands, where eleven of the resident species are mentioned: *Ischnura genei*, *Anax ephippiger, A. imperator*, *A. parthenope*, *Orthetrum brunneum, O. cancellatum*, *O. ramburi* (= *O. coerulescens anceps*), *Crocothemis erythraea*, *Sympetrum fonscolombii*, *S. striolatum*, and *Selysiothemis nigra*. An information pamphlet by Cilia (1972), also described a number of species already mentioned by Anthony Valletta. Maltese odonate behaviour and ecology were studied by the author in the early 1990's. This work was the first ever to shed some light on how local dragonfly species adapt strategies to survive in the water-limiting habitats of the Maltese Islands (Degabriele, 1992).

Apart from published material, a number of field workers and observers have collected odonate specimens. All material in these collections dates from the 1950's to the present date. Such collections include the Guido Lanfranco collection (material captured 1950's - 1970's) housed at the National Museum of Natural History (NMNH) (Degabriele, 2008), the Paul Sammut collection who contributed material to the NMNH odonate collection (captured between 1970's - 1990's), and the private collections of Stephen Schembri (who also donated to the NMNH; 1960's - 1980's), Louis Cassar (1970's - 1990's), Martin J. Ebejer (1970's - 1990's), Anthony Seguna (1970's - 2000's), Arnold Sciberras (1990's - 2000's) and Denis Magro (1990's - 2000's).

It is worth nothing that, while interest in collecting and observing Maltese Odonata increased from the 1960s to the 1990s, it has declined during the past two decades. This decline in interest could have been caused by the lack of exposure of younger generations to the Maltese countryside. Recent progressive degradation of the Maltese countryside owing to rapid urban development could be one of the reasons for such lack of exposure. It is likely that such urban development may have resulted in younger generations showing less inclination towards knowing more about natural habitats surrounding them. This rise and fall in interest on the matter of Odonata could also have affected the information discovered about local Odonata, which may not necessarily reflect the actual date of introduction of any species to the islands.

Research by the author and colleagues (Ebejer *et al.*, 2008), by Sciberras *et al.* (2009), and by Gauci & Sciberras (2010) have added five species, these being: *Aeshna mixta*, *Trithemis annulata, Orthetrum trinacria*, *O. nitidinerve*, and *O. chrysostigma*. Sciberras & Sammut (2008) and Corso *et al*. (2012) also record the finding of *Calopteryx virgo* and *C. haemorrhoidalis* from collected local material dating from 1970's - 1990's. The specimens mentioned by these authors are probably vagrant records. No other sightings of either of these species exist to date.

Balzan's recent study has revealed the relationships that exist between odonate assemblage structure and diversity with habitat variables of local habitats and surrounding agricultural landscapes (Balzan, 2012).

MATERIAL AND METHODS

The printed material and the mentioned collections have been reviewed by the author, Ebejer and Sciberras (Ebejer *et al.*, 2008) and were used as a source of reference for the present work. This was supplemented with fieldwork observations at different locations in Malta between Autumn 2012 and Autumn 2013, where population counts of around 20 to 30 minutes were carried out in different locations and at different times of the day. Some specimens were captured for close examination but were released afterwards. From this point onwards, whenever fieldwork by the author is mentioned, it will refer to these particular sessions.

Rather than using traditional keys to identify the different suborders, families, genera and species (larvae) of odonata, diagnostic tables in the style of Dijkstra & Lewington (2006) have been used in this work, since such tables can show all the morphological and behavioural differences at a glance. The choice of diagnostic characters relevant to the odonata that occur in the Maltese Islands has been based mainly on personal observations by the author, as well as the descriptions from works on the Odonata of Europe and North Africa by d'Aguilar *et al.* (1985), Miller (1995), Askew (2004), and Dijkstra & Lewington (2006). However, identification of adult odonates was done using a traditional key due to the large number of diagnostic characteristics included therein. Anatomical abbreviations in tables and texts are discussed in the "Adult Anatomy" section (pp. 8 - 16).

Drawings of diagnostic anatomical features of adults and larvae have been produced from examination of live specimens and photographs taken by the author as well as of drawings from Conci & Nielsen (1956), Carchini (1983), Gerken & Sternberg (1999), Askew (2004), and of photographs from Cham (2007, 2009) and Doucet (2010). Detailed descriptions of the 17 recorded odonate species of the Maltese Islands are found from page 47 to 95. Each species description is accompanied by a number of illustrations of the species. All photographs were taken from the Maltese Islands except for figs. 32, 34a (*Aeshna mixta* - Schrozberg, Baden-Württemberg, Germany); 48a-b (*Orthetrum brunneum* - Rechbach, Kupferzell, Baden-Württemberg, Germany); 51a (*O. nitidinerve* male - Altipiano di Abbasanta, Macomer, Sardegna, Italy); 51b (*O. nitidinerve* pair - Giara di Gesturi, Medio Campidano, Sardegna, Italy); 52, 66b (*O. chrysostigma*, *Selysiothems nigra* female - Tozeur Oasis, Tunisia); 59a-c (*Sympetrum striolatum* male and female - Schwäbich Hall, Baden-Württemberg, Germany); 59b (*S. striolatum* female - Leiden, the Netherlands), 68a (*Pantala flavescens* - Mauritius) 69 (*Calopteryx virgo meridionalis* - le Largue, Forqualiquier, Haute Provence, France); 70a-b (*C. haemorrhoidalis* -Rio CiXerri, Siliqua, Cagliari, Sardegna, Italy). The order in which the species appears follows Dijkstra & Kalkman (2012). The only exception is the sequence of species of the genus *Orthetrum*, where the order was arranged in such a way as to include similar species together. This would then facilitate their identification to species level.

English vernacular names. Dijkstra & Lewington (2006) fashioned English vernacular names for all odonate species occurring in Europe and the Mediterranean, since not all odonate species inhabiting the Mediterranean had an English vernacular name. This work makes use of such names. Where the vernacular names by the above authors do not match the already existing English vernacular names (provided by the British Dragonfly Society, or BDA), the second is provided in brackets.

Maltese vernacular names. While the official Maltese name for dragonflies is “mazzarell”[29], many regional variations are used to refer to the organisms. An old regional and colloquial name is “mewt” (death)[30]. Dingli farmers, call them “Ċikku Ġwiebi” (translated as “water-reservoir Francis”) because of the adults’ habit to frequent water reservoirs (Sciberras, 2007). Colloquially, dragonflies are generally referred to as “ħelikopter” (helicopter), because of their particular body shape and flight mechanism. Maltese species names for dragonflies are hard to find, as locals refer to the organisms simply by the above-mentioned names. A Maltese vernacular name for some species was coined by Sultana *et al*. (1995), and by Falzon (2007) based on a morphological and distribution point of view. For this work, previously available names were used, while the ones that did not exist were proposed by the author, a times with contributons from Sciberras, and with consultancy from Falzon. No Maltese vernacular name was included for the *Calopteryx* species since these are considered one-time vagrants.

The status of each species on the islands is described as: very common, common, rather common, scarce, rare, very rare and single record (for one or a single cluster of records obtained during one season or year), depending on the frequency of sightings and/or specimens available in collections. Moreover, the distribution is described to be either localized or widespread depending on the range of sightings/available specimens across the islands.

Measurements quoted are for body length (Bl) and hindwing length (Hw) and mostly follow Dijkstra & Lewington (2006), since measurements taken locally fell within the ranges quoted by these authors.

Distribution maps next to each species (except in the case of single records or single record clusters) are based on data from specimens found in collections, as well as on field observations carried out by the author. Colour codes for the maps are as follows:

[29] The word “mazzarell” is quoted in some dictionaries (e.g. Busuttil, 1941; Bugeja, 1999) as being a drumstick, or quill for knitting needles, or even a thick nail used for hanging heavy items onto walls. Similar word comparisons are found in the odonate genus name *Gomphus*, taken from the Ancient Greek 'γομφος' (gomphos) which means 'plug' or 'large wedge-shaped *nail*' (Liddell & Scott, 1980), as well as the American vernacular name “darners” used for many species of the genus *Aeshna*, after their resemblance to darning needles.

[30] Corbet (2004) also mentions that European civilizations viewed dragonflies as sinister and associated with evil and death.

Genus and species texts discuss specific diagnostic features. For genera with only one species, or where only one species occurs on the Maltese Islands, the species and genus texts have been merged. The species of the family Calopterigydae are treated in less detail than other species, since the very few existing records indicate one-time vagrant specimens from the 1980's. Descriptions of adults are based mainly on personal observations and the descriptions from Conci & Nielsen (1956), d'Aguilar *et al.* (1985), Askew (2004), and Dijkstra & Lewington (2006), but comparing only local species. The style of the descriptions is based on Dijkstra & Lewington (2006). Brief descriptions of the larvae are also given, based on personal observations by the author, and also from texts on larvae and exuviae of European Odonata by Gerken & Sternberg (1999), Cham (2007, 2009) and Doucet (2010). The order in which the data is presented in the species descriptions is described as follows:

An identification section for each species includes body and hindwing lengths of the species, a general description of the features, followed by a species description as seen in the field (at close range) and, where relevant, on close inspection (features that require close scrutiny and perhaps some form of magnification). This is followed by a brief account of the behavior of the species. The occurrence section provides information on the local and worldwide distribution ranges, based on local records and the aforementioned works on European Odonata as well as the work by Boudot *et al.* (2009), together with its habitat preference, and flight season. The larval stages section generally describes the appearance and behavior of the final instar (sometimes refered to as F0), diagnostic tables for which, are found in tables 13 to 21 (pp. 105 - 113).

IDENTIFICATION OF SUBORDERS, FAMILIES AND GENERA

Odonate suborders

The odonates of the Maltese Islands belong to the Suborder Zygoptera and Anisoptera. Odonates from these suborders can be distinguished by the features listed in table 1:

Table 1. Diagnostic features that distinguish suborders Anisoptera and Zygoptera.

Diagnostic characters	Eyes	Wings at rest	Discoidal cell	Pterostigma	Male anal appendages	Female ovipositor	↴
Smaller and of slender build. Wings with simple venation, similarly shaped and petiolate. Hindwing narrowed in basal half (widest part beyond midpoint). Weak flyers with slow wingbeat. Females endophytic	Widely separated and do not cover top part of head	Held together over. abdomen[31]	Four-sided (quadrilateral)	Rather short and usually absent in calopterygids (see table 2)	Two pairs	Present	**Zygoptera**
Larger and more robust. Wings never petiolate, with complex venation, and hind wing considerably wider than forewing. Strong flyers with very fast wingbeat. Aeshnid females endophytic, all others exophytic	Large and globular, and confluent (touch top of head)[32]	Kept wide open	Three-sided (triangle and hypertriangle)	Elongated	One pair of superior appendages and a one single inferior appendage	Only in aeshnids	**Anisoptera**

[31] except in Gomphidae.
[32] except in Lestidae, where wings are held open.

Odonate families

Suborder Zygoptera

The three zygopterans recorded from the Maltese Islands, belong to two families - Calopterigydae and Coenagrionidae. Despite the fact that the calopterigyd species are considered as vagrants (pg. 95), the two families are still distinguished hereunder (table 2):

Table 2. Diagnostic features that distinguish the families Calopterigydae and Coenagrionidae.

Diagnostic characters	Body length	Head	Pterostigma	Metallic body coloration	↓
Wings coloured. 18 A_x in forewing. Quardrilateral is a narrow rectangular series of many cells. Legs long, spidery and with long bristles	> 40 mm	Not as follows	Absent in males. Pseudopterostigma (weakly defined and subdivided by cross veins) in females	Always present, particularly in males	**Calopterigydae**
Wings clear. 2 A_x in forewing. Cells in wing mostly quadrangular. Quardrilateral skewed trapezium. Tibiae thin and often dark	< 40 mm	About 2x as wide as long, and with pale band in front of vertex, or behind it/ or with post ocular spots	Diamond-shaped. May be bi-coloured in males of some species	Almost never present	**Coenagrionidae**

Suborder Anisoptera

The 16 local species records of anisopterans belong to two distinct families - Aeshnidae and Libellulidae. Members of these families are distinguished by the features included in table 3.

Table 3. Diagnostic features that distinguish the families Aeshnidae and Libellulidae.

Diagnostic characters	Body length	Body colour	Eyes	Acute corner of Triangle	Auricles	Female	Behaviour	➔
Labium consisting of large middle lobe with median structure -lateral lobes widely separated, and middle lobe of labium entire or with only a minute apical notch. A_x with two primary antenodals prominent; while remaining ax not aligned over costal and subcostal spaces. Discoidal cells similarly shaped in both wings and equidistant from arculus. Pterostigma with oblique crossvein brace at proximal end	< 50 mm	Blue spots always present, coloured by internal pigments. Body never pruinose	Contiguous dorsally	Points outwards	Can be present laterally on 2nd abdominal segment	With complete ovipositor. Ovipisit endoph-ytically	Flies for long periods. Perches seldom. Fast powerful flyers. Perch occasionally amongst trees and bushes hanging vertically	**Aeshnidae**
None of the above	Almost never < 50 mm	Various colours though seldom metallic. Can be pruinose and red (except *Selysio-themis*)	Posterior margin without prominence. No obvious indentation on external posterior edge	Points backwards	Never present	No ovipisitor present (vulvar scale). Oviposit exoph-ytically	Short, but capable of performing occasional long flights. Perches often and for longer periods	**Libellulidae**

Dragonfly genera

Suborder Anisoptera, Family Aeshnidae

The four locally occurring aeshnid species belong to two distinct genera – *Aeshna* and *Anax*. Members of these families are distinguished by the features outlined in table 4:

Table 4. Diagnostic features that distinguish between members of the genus *Aeshna* and those of the genus *Anax* occurring in the Maltese Islands.

Diagnostic Characters	Body colour	Ir3 fork	Rows of cells above rspl and mspl	Females	
Anal triangle present with 2 - 4 cells. Hindwing base angled. End of rspl points towards a part of the wing posterior of the tip. R3 forms regular curve under pterostigma. Pterostigma less angulated. Abdomen is waisted. Auricles on S2 present in males	Thorax inlaid with coloured bands, and abdomen with coloured spots	Present	3 - 5	Oviposit alone	***Aeshna***
Anal triangle absent. Hindwing base smoothly rounded. End of rspl points towards a part of the wing anterior of the tip. R3 is abruptly arched forward near distal end of pterostigma Abdomen is not waised. Auricles on S2 absent in males	Thorax often uniform, not banded. Abdomen not banded, uniformly green, blue or brown with broad black mid dorsal stripe	Absent	4 - 5	Oviposit alone or in tandem	***Anax***

Suborder Anisoptera, Family Libellulidae

The 12 libellulid species occurring in the Maltese Islands belong to six genera, these being *Orthetrum*, *Sympetrum*, *Crocothemis*, *Trithemis*, *Selysiothemis* and *Pantala*. Two diagnostic tables have been used to separate these genera, one showing general features (table 5a) and the other includes wing features (table 5b).

Table 5a. Diagnostic features (general) that distinguish between the six genera of libellulids occurring in the Maltese Islands.

Diagnostic characters	Body colour	Amber patch on hindwing	Pterostigma	↓
Not as follows	Overall colour varies but never bright red. Abdomen in adult males usually becomes pruinose (grey blue)	Absent	Not as follows	***Orthetrum***
Prothorax with well developed raised posterior lobe	Overall brown and red or red in adult males. Females and young males yellowish with lateral and dorsal black stripes, but may also be reddish	Sometimes present	Not as follows	***Sympetrum***
No black markings on body. Legs reddish	Overall colour bright red in males, yellowish in females and young males	Present	Approx. 3.5 mm. Pterostigmal membrane uniformly coloured	***Crocothemis***
Legs mainly black	Adult males red and pruinose (giving an overall purplish look). Females and young males yellowish becoming brown	Present	Approx. 2.6 mm. Dark	***Trithemis***
Abdomen regularly shaped	Adult males blackish. Females and young males a sandy colour with back dorsal and lateral stripes	Absent	Short and pale	***Selysiothemis***
Larger body. Legs striped. Tranverse ridge on S5. Appendages long	Males yellow suffused orange red. Females more yellow	Faint brownish patch on tip of hindwing	Pterostigma of hindwing shorter than that of the forewing	***Pantala***

Table 5b. Diagnostic features (wings) that distinguish between the six genera of libellulids occurring in the Maltese Islands (modified after Askew, 2004).

<table>
<tr><th>Feature</th><th>Orthetrum</th><th>Sympetrum</th><th>Crocothemis</th><th>Trithemis</th><th>Selysiothemis</th><th>Pantala</th></tr>
<tr><td>Fw A_x</td><td>11 - 14</td><td>8½ - 10 ½</td><td>9 +</td><td>9 ½ - 11 ½</td><td>6 - 8</td><td>12 - 14 ½</td></tr>
<tr><td>Fw subtriangle cells</td><td colspan="4">3</td><td>1</td><td>3-5</td></tr>
<tr><td>Fw disciodal cell crossveins</td><td colspan="4">1</td><td>0</td><td>1</td></tr>
<tr><td>Cells adjacent to discoidal cell distally</td><td colspan="4">3</td><td>2</td><td>3</td></tr>
<tr><td>Fw post discoidal field (trigonal space) widens appreciably</td><td>Yes</td><td>No</td><td>Yes</td><td colspan="3">No</td></tr>
<tr><td>Distal cell rows between1R3 - rspl</td><td>1 - 2</td><td colspan="2">1</td><td>2</td><td>1</td><td>2</td></tr>
<tr><td>Hw discoidal xveins</td><td>0 - 1</td><td colspan="5">0</td></tr>
</table>

Note: Fw = forewing, Hw = Hindwing; ½ refers to an incomplete distal antenodal vein. All species have one bridge crossvein and one cubitoanal crossvein in hindwing.

ANNOTATED SPECIES AND DESCRIPTIONS

Suborder Zygoptera (Damselflies)

Three species, two belonging to the family Calopterigydae and the other to the Family Coenagriondae, have been recorded in the Maltese Islands. Since no recent live records of *Calopteryx* have been observed to date, these species are described later under the section entitled "Vagrant Records".

Family Coenagrionidae

This is the largest family of European damselflies, and includes a large number of species with worldwide distribution. Coenagrionids are small to medium-sized, slender-bodied, and narrow winged damselflies, with a short or very short pterostigma. Their bodies are rarely metallic in coloration. The wings of these damselflies are small as compared to those of other zygopteran families, petiolate and unpigmented, with most of their cells being rectangular in shape, giving the impression of a rather simple, grid-like venation in some species. Wings are usually kept closed when at rest. Males are territorial and brightly marked black and blue or black and red. Females are somewhat more cryptically coloured.

Adults are typically found in large numbers amongst vegetation bordering the waters in which they developed, however females may also be found away from the water. One species, belonging to the genus *Ischnura*, is recorded in the Maltese Islands.

Ischnura genei (Rambur, 1842)

(Figs. 27-31)

Island Bluetail
Damiġella

Status: Common and widespread.

Bl: 26 - 34 mm.
Hw: 12 - 18 mm.

IDENTIFICATION: General. A small delicate species with a distinctive 'tail-light' at the posterior tip of the abdomen, usually blue in males (Figs. 30a-b) and andromorph (male-like) type females. Prominent post-ocular spots are found at the back of the head. Like all members of the *elegans* group (to which the species belongs), three female varieties occur (Figs. 28a-c, 29a-d). Type A, is andromorph i.e. resembles males in coloration. Types B and C, look distinctly different from males and are called gynomorphs (Dijkstra & Lewington, 2006). The features of these varieties are summarised in table 6.

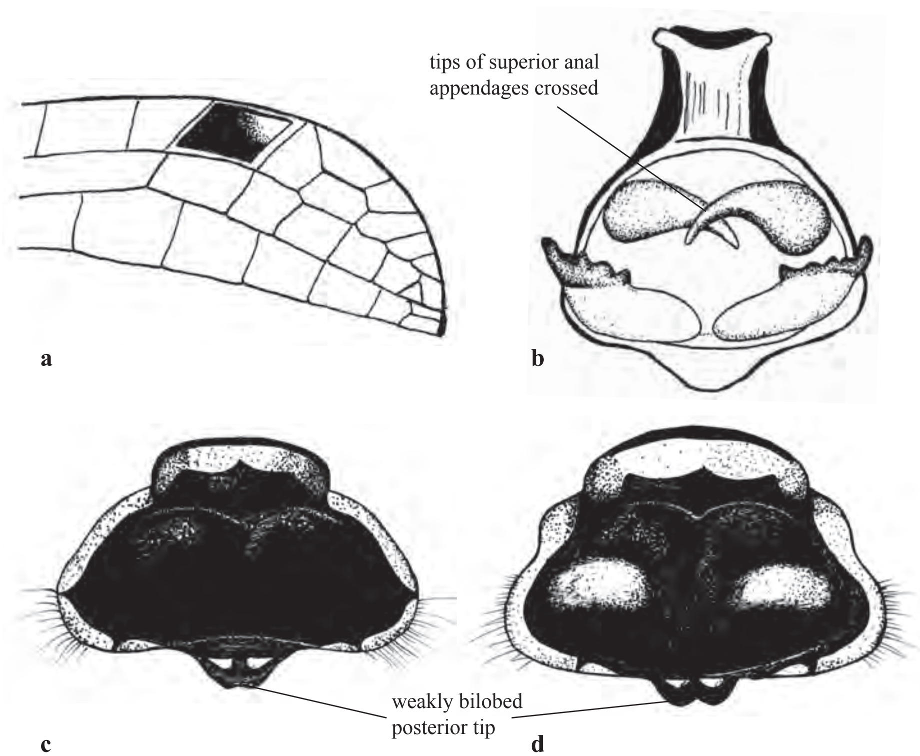
In the field. A slow-flying species with distinctive flight described as "bobbing" by Miller (1995) for *I. elegans*, a closely related species[33]. Face, thorax and abdomen base in males and andromorph type females is green to turquoise (as compared to *I. elegans*, where these regions are blue). All female types can have black markings on S8.

[33] *Ischnura genei* was formerly considered a subspecies of *I. elegans*. The latter species has minor physiological differences and also different distribution range from *I. genei*.

On close inspection. Males (Figs. 30a-b, 31) have a distinctive diamond shaped, bi-coloured pterostigma (Fig. 27a), usually the blackish on the side facing the wing base and whitish on the side facing the wing tip. Also distinctive is the occurrence of the vulvar spine at the base of the ovipositor on the underside of S8 in females.

Table 6. Female morphs of *Ischnura genei* (Figs. 28a-c, 29a-d) for the Maltese Islands (from Dijkstra & Lewington, 2006: 90).

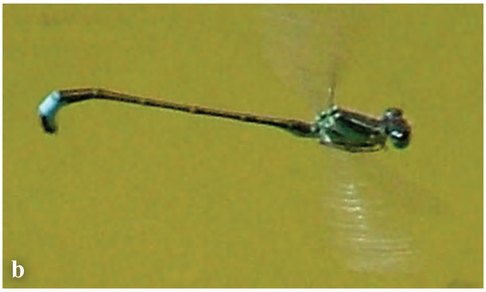
Type	Colour		'Tail – light' coloration	Humeral characters
	Teneral	Mature		
A	Lilac to orange	Bright bluish - green	Blue	Lateral black lines present
B	Lilac	Olive green to brown	Brown	Lateral black lines present
C	Pink or orange	Brown or green	Brown	Lateral black lines absent



Figures 27a-d: *Ischnura genei*. **a**: bicoloured pterostigma in males; **b**: male appendages; **c**: male pronotum; **d**: female pronotum, with a low weakly bilobed posterior tip, typical of the species.

Figures 28a-c: *Ischnura genei* females dorsal view. **a**: type A; **b**: type B; **c**: teneral type C.

Figures 29a-d: *Ischnura genei* female lateral view. **a**: type A. ; **b**: type B; **c**: Teneral type C; **d**: mature type C.



Figures 30a-b: *Ischnura genei* males. **a**: at rest; **b**: in flight.

Figure 31: *Ischnura genei* tandem pair.

Ischnura genei is distinguished from *I. elegans*, by the following features: (i) the posterior end of the pronotum has the apex of the process of the hind lobe distinctly incised in both sexes (Fig. 27c-d); (ii) pterostigma of forewing is slightly larger than that of hindwing; (iii) male superior anal appendages are approximately similar in length and thickness and the tips of these appendages appear to cross each other when seen from behind (Fig. 27b).

Behaviour. Males are territorial and can be rather aggressive towards conspecific rival males while fighting for females, with the victor occasionally eating its opponent. Copulation takes rather long to reach completion, and females oviposit alone but are often guarded by the male.

OCCURENCE: Habitat. The species prefers standing or running waters with rich vegetation. Miller (1995) describes *I. elegans* and *I. pumili*o as being able to survive in brackish water. Likewise *I. genei* has been recorded to breed in brackish water at il-Magħluq, M' Scala (Degabriele, 1992).

Local distribution. This species is widely distributed in the Maltese Islands, and is to be found, often in large numbers, wherever there are water bodies where nearby vegetation abounds.

Global distribution. *Ischnura genei* is endemic to the Mediterranean islands of Corsica, Sardinia, Sicily, Malta and Elba and Giglio, the latter being two islands off the coast of Tuscany, and the only locations in which *I. genei* and *I. elegans* are reported to coexist (Askew, 2004; Dijkstra & Lewington, 2006).

Flight season. Locally recorded between March and October.

Larval stages. Larvae of the genus *Ischnura* are slender and have three distinct leaf-like caudal lamellae that taper to a point (Fig. 14). The head appears relatively small compared to its body size. The labial mask is flat and triangular and narrower than in Aeshnidae. Larvae of *I. genei* have been observed in small ponds, slowly flowing streams and drainage channels.

Suborder Anisoptera

Family Aeshnidae

Aeshnids are large, formidable, conspicuous, fast-flying insects with long slender abdomens. Their eyes are very large and broadly confluent. They can feed on relatively large prey, such as butterflies and spiders which they capture and devour on the wing. When at rest in vegetation, they adopt a vertical position (Fig. 34a, 37b-c). Some species have migrating habits. Females have an ovipositor below the end of the abdomen, similar to that in zygopterans, being short and provided with serrated valves to pierce vegetation for laying eggs endophytically. Larvae are voracious, and can be relatively territorial. Larval stages and male primary and secondary genitalia are very similar amongst species. The larval labial mask is flat and triangular in shape (Fig. 74a).

In the Maltese Islands this family is represented by four species accomodated in two genera, the genus *Aeshna* with a single species discussed here under and the genus *Anax* discussed later.

***Aeshna mixta* Latreille, 1805**
(Figs. 32-34)

Migrant Hawker
Sultan Rari

Status: Very rare.

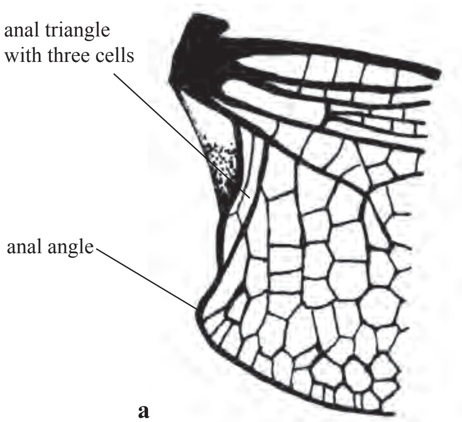
Bl: 56 - 64 mm.
Hw: 37 - 42 mm.

IDENTIFICATION: General. The smallest aeshnid species to inhabit the Maltese Islands. The body is typically dark with a series of coloured bands on the thorax and a pattern of coloured spots on the abdomen. The build of this species is slightly more slender than *Anax* species, the abdomen is waisted and auricles are present in males on the second thoracic segment.

In the field. Male abdominal spots are bluish[34], while in the somewhat lighter coloured females, abdominal spots are yellowish-green. In both sexes, the thorax has a pair of distinctive short, yellow antehumeral stripes. Moreover, S2 in both sexes is marked dorsally by a yellow "T" or nail shape (Fig. 32b). Anal appendages (Fig. 33) are rather long but more slender than those of *Anax* species. Legs are mainly black.

[34] The bluish areas can turn purplish in colder weather (Dijkstra & Lewington, 2006)

On close inspection. Wing venation differs from *Anax* in that: (i) R_3 forms a regular curve under pterostigma; (ii) $1R_3$ is forked towards the wing apex; (iii) and the pterostigma is less angulated. Rspl points towards part of the posterior wing tip. There are three rows of cells above rspl and mspl. An anal angle and anal triangle with 2-4 cells are present in males (Fig. 32a). Hindwing base is angled. Male superior anal appendages more than three times the length of S10 and with no sub-basal tooth when viewed laterally (Fig. 33). Female appendages are as long as S9-10.



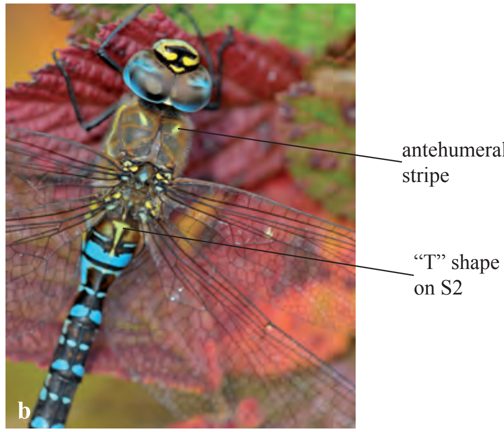


Figure 32a-b: *Aeshna mixta.* **a**: hindwing base; **b**: male showing short antehumeral stripes, and S2 marked dorsally by a yellow “T” or nail shape.

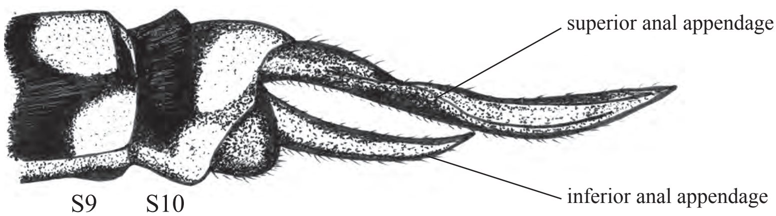


Figure 33: *Aeshna mixta* male anal appendages lateral view.

Figure 34a-b: *Aeshna mixta*. **a**: male; **b**: Ovipositing female.

Behaviour. *Aeshna mixta* is a species with strong migratory tendencies. It has been observed in the Netherlands by the author while on hunting patrols along trees in rather large groups during the eaarly afternoon. Like all members of the genus *Aeshna*, females oviposit alone.

OCCURRENCE: Habitat. This species prefers standing or slow moving water bodies that abound in vegetation. It can also tolerate brackish water.

Local distribution. First recorded by Ebejer in 1976 from Balzan, Malta (Ebejer *et al.*, 2008)[35]. A small number of females in oviposition have been recently recorded and photographed by Ruf *et al.* (2011) (Fig. 34b) from a pond to the south of Xagħra, Gozo. The authors also recorded the presence of a male in the mentioned locality.

Global distribution. *Aeshna mixta* is found across most of Europe and the Mediterranean extending to the east up to Japan. Its range is currently extending northwards (Dijkstra & Lewington, 2006).

Flight season. Local records span between April - November. In the Mediterranean Region it is most common between May - December. In northern countries, flight periods are shorter.

Larval stages. Larvae of *A. mixta* possess a non-rounded head, typical of the genus *Aeshna.* Eyes are broader than long. The labial mask is broader than in *Ischnura.* Larvae grow smaller and are slightly more slender than those of *Anax*. Final instar larvae never grow longer than 38 mm (Cham, 2007). Larval development can usually take one year in southern countries (d'Aguilar *et al.*, 1986). No larvae have been recorded locally to date.

The genus *Anax* Leach, 1815

Large insects, amongst the largest on the Maltese Islands. Fast powerful flyers, they patrol effortlessly over the centre of large water bodies. The thorax is not banded and the body is uniformly green, blue or brown with a broad black mid-dorsal stripe on the abdomen. Males have no auricles on S2. Wings differ from *Aeshna* in that: (i) IR_3 is not forked towards wing apex; (ii) R_3 is abruptly arched forward near distal end of pterostigma; (iii) the pterostigma is more angulated; (iv) rspl curves forward strongly with distal end pointing between pterostigma and wing tip; (v) no anal triangle present and (vi) anal angle curves smoothly. Larvae behave as claspers (Corbet & Brooks, 2008). Three species of *Anax* occur on the Maltese Islands. Table 7 shows diagnostic differences between the three species, while table 17 shows diagnostic differences between the larvae of these species.

[35] This specimen is also first mentioned in the unpublished work by the author (Degabriele, 1992).

Table 7. Features that distinguish between *Anax* species (modified from Dijkstra & Lewington, 2006).

Feature	*Anax imperator*	*Anax parthenope*	*Anax ephippiger*
Size	Large (78 mm long)	Very slightly smaller than *A. imperator* (66 - 75 mm)	Distinctly smaller (76 - 84 mm)
Eyes	Green to blue above and yellow-green below (Fig. 35a)	Uniformly green sometimes tinged with yellow/ blue and/ or brown (Fig. 35b)	Brown above and (greenish) yellow below - never blue (Fig. 35c)
Frons	Bluish bar behind crest with black pentagon at base	Bluish bar behind crest and black triangle at base	Black bar on crest and never blue at base
Female	No occipital tubercles	With two occipital tubercles	No occipital tubercles
Thorax	Green	Purplish brown	Brown
Wings	Sometimes tinted between triangle and tip	Often conspicuously tinted brownish between node and pterostigma	Often inconspicuously tinted in the central part
Abdomen	Thick and longer than hindwing	Thick and longer than hindwing	Slender and as long as hindwing
S1	Green or sometimes blue	Brownish	Brown
Basal ring on S2	Green (yellow when young)	Yellow	Brown-yellow
Male abdomen	Bright blue on S2-10	Marked with bright blue only on S2 and base of S3 (pale markings thereafter duller and darker)	Small bright blue only on S2 and base of S3 (thereafter duller and darker)
Blue Saddle	Not distinct since S2-10 are also blue	Distinct wrapped around segment extending onto base of S3	Distinct in males - less in teneral males and females. Does not wrap round segment (sides dull yellow)
Ground colour S3-7	Green turning blue in mature individuals	Brown- bluish	Brown/ straw coloured
S8-10	Colour markings similar to preceding segments sometimes brownish	As before, sometimes blacker	Blacker than before leaving only clearly defined pale spots at hind corners of segments
Male superior anal appendages	Expanded medially only about three times as long as max breadth apically rounded without a clearly defined sub basal tooth (Fig. 36a-b)	Bear an apical point with a small spine at the tip (Fig. 36c-d)	Tapered and pointed. Not as before (Fig. 36e-f)
Male inferior anal appendage	$^{1}/_{3}$ as long as superior (apically truncated in dorsal view). Denticulated (Fig. 36a-b)	Less than $^{1}/_{5}$ as long as superior, apically bilobed, denticulated and without any clearly defined sub basal tooth (Fig. 36c-d)	¼ of the length of the superior appendage, triangular in shape and highly denticulated (Fig. 36e-f)

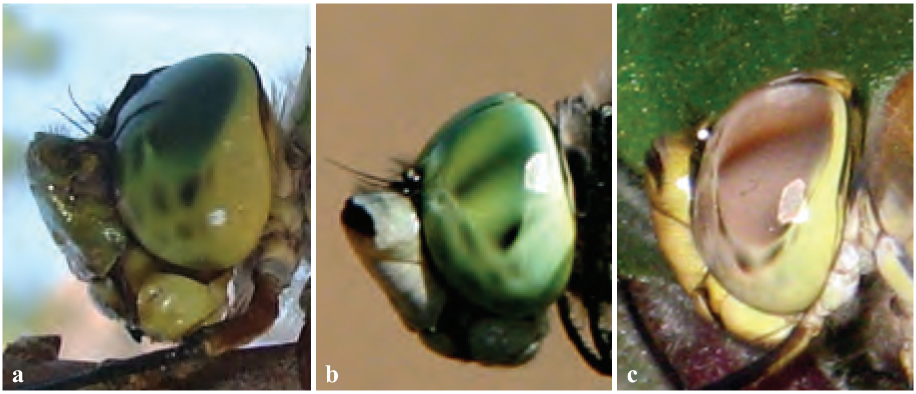
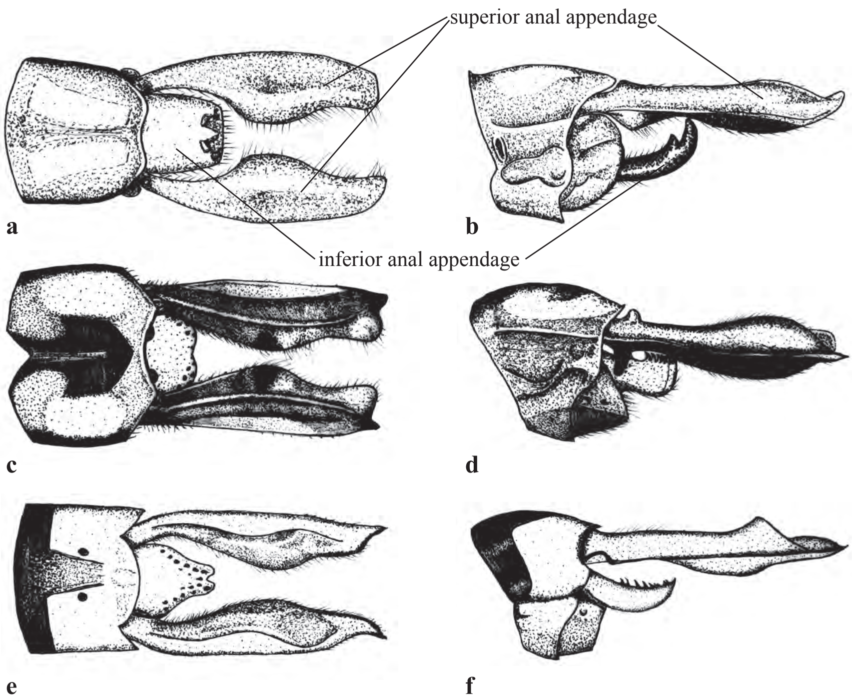


Figure 35a-c: Heads of *Anax* spp. **a**: *A. imperator* with eyes that are green or blue above, and yellow to green below; **b**: *A. parthenope* with eyes that are uniformly green; **c**: *A. ephippiger* with eyes that are brown above and yellowish below.



Figures 36a-f: *Anax* male anal appendages dorsal and lateral views. **a** and **b**: *Anax imperator*; **c** and **d**: *A. parthenope*; **e** and **f**: *A. ephippiger*.

Anax imperator Leach, 1815

(Figs. 36a-b, 37a-d, 39a)

Blue Emperor (Emperor Dragonfly)
Sultan

Status: Very common and widespread.

Bl: 76 - 84 mm.
Hw: 45 - 52 mm.

IDENTIFICATION: General. A common, conspicuous, large and colourful dragonfly. The blue and green males can be observed patrolling the skies even in the city centres.

In the field. Males (Fig. 37c) and some older females have a green thorax, and an abdomen which is predominantly (except for S1) a brilliant blue. Mature males can also have blue dorsal markings on the thorax just before the wings. Females (Figs. 37a-b) and tenerals are predominantly green. Both sexes have a dorsal brownish black line on the abdominal segments. Body colour is known to reversibly change with temperature (Corbet, 2004)[36]. The eyes are greenish-blue on the upper side and yellowish-green underneath. The frons has a black pentagon-shaped marking that distinguishes it from other *Anax* (Fig. 37b). Wings are hyaline and slightly yellowish brown from the triangles to wing tips. Legs are mainly black.

On close inspection. Male inferior anal appendage (Figs. 36a-b) is about $^1/_3$ - $^1/_4$ the length of the superior appendages and are squarish in shape. A ridge of teeth-like structures (denticles) are present on outer tip. Male superior appendages are shorter than S9-10 and have broadly rounded tips. Female anal appendages are leaf like and apically pointed. In females, the back of the occiput is smooth (Fig. 39a).

Behaviour. Males patrol open water, reed beds, ponds and lakes. Females typically fly with their abdomen slightly downwards. They have been observed to show a repertoire of responses to interference from conspecific males/predators, which include changes in flight direction, rapid hovering, and refusal behaviour towards male involving downward curving of abdomen, and downward apical flight (Corbet, 2004). Ovipositing females have been observed by the author to show agressive behaviour towards other conspecific and heterospecific ovipositing females. Females are also known to show heterospecific aggressive behaviour, which according to Corbet, (2004) could give the specimens enhanced access to foraging. Oviposition occurs by the unaccompanied females (Fig. 37a) in mats of aquatic vegetation and floating debris.

Locally, specimens have been recorded by the author to prey on large insects like butterflies (e.g. *Pieris brassicae*) and even smaller dragonflies (e.g. *Sympetrum*) (Degabriele, 1992).

OCCURRENCE: Habitat. A standing water loving species. Also frequents and breeds in man-made reservoirs. Exuviae have been collected by the author from brackish water ponds at Magħluq, M'Scala.

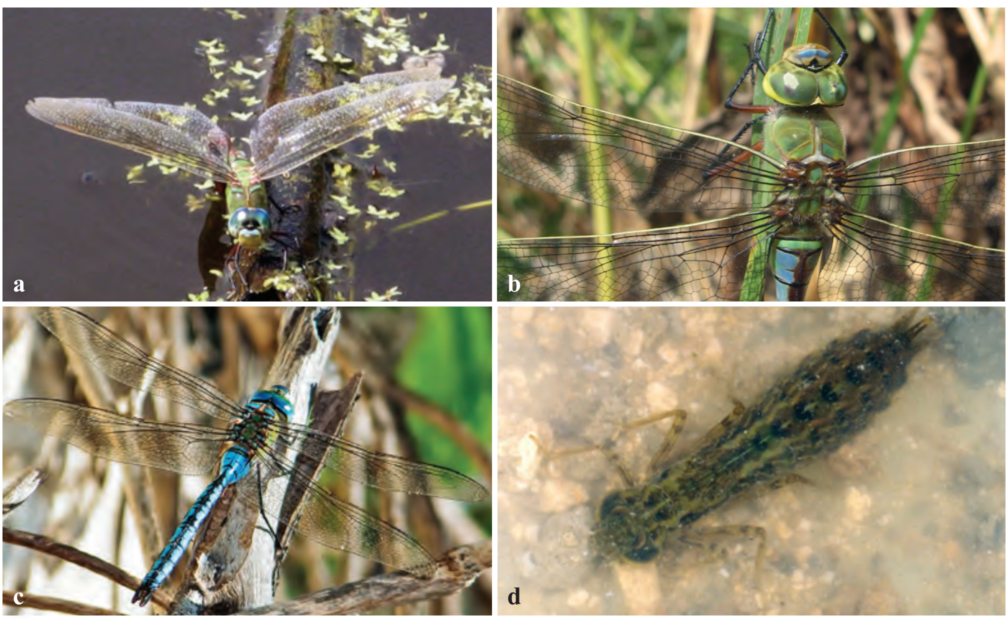
[36] This feature, also shared with some tropical species may be an adaptation to avoid detection by predators (McGavin, 2001; in Silsby, 2001).

Local distribution. The species has been recorded extensively across the Maltese Islands. Corso *et al*. (2012) argue that this species has recently declined and is being replaced by *A. parthenope*; however this claim could have have been influenced by: (i) the fact that this species tends to locally emerge earlier in the year than *A. parthenope* (Degabriele, 1992; Balzan, 2012) therefore the latter species is more common in places where the former is found in Spring; and (ii) the fact that *A. imperator* males typically occur in smaller numbers over the same area than *A. parthenope* because of the larger territories they establish.

Global distribution. *Anax imperator* is found throughout most of Europe, but also across the Middle East, western Asia as far as Pakistan, most of Africa and the Azores.

Flight season. Locally recorded from January till October, but occurs in greater numbers in Spring. Shorter flight periods in northern countries. Similar flight periods in Northern Africa.

Larval stages. Larvae (Fig. 37d) are large (exuviae 45 - 56 mm, Cham, 2007) longish and cylindrical in shape. The head is circular with eyes being longer than broad. The back of eyes line up in a "V" shape pointing to the back of the head (Doucet, 2010) (Fig. 76a). Lateral spines are present on the thorax with that on S9 being slightly longer than in *A. parthenope* ($^1/_2$ the size of the cerci; Cham, 2007; Doucet, 2010). In males, the male projection (Fig. 77c) is longer than in male *A. parthenope* larvae (Fig. 77b).



Figures 37a-d: **a**: *Anax imperator* ovipositing female; **b**: *Anax imperator* female close up of head (showing a black pentagonal mark on frons) and thorax; **c**: *Anax imperator* male; **d**: *Anax imperator* larva.

Larvae move around on the pond bed, feeding on small fish and tadpoles, and can also show cannibalistic traits. They prey mostly on the predominant species available. They tend to be territorial, and have been observed to show agonistic behaviour (Corbet, 2004). Locally take around a year to develop into an adult, however exuviae have been collected by the author from Wied Għollieqa, a valley where the rainwater pool that forms dries up completely in Summer[37] (Degabriele, 1992).

Anax parthenope **(Sélys, 1839)**
(Figs. 38a-d, 39b)

Lesser Emperor
Sultan Sewdieni

Status: Very common and widespread.

Bl: 66 - 75 mm.
Hw: 44 - 51 mm.

IDENTIFICATION: General. A large darkish species, slightly smaller than *A. imperator*, with conspicuous green eyes and a blue saddle marking on the anterior abdomen (Fig. 38a).

In the field. In flight one gets the impression that *A. parthenope* is almost black. Eyes are greener than in *A. imperator.* The thorax is brownish violet, while the abdomen is greenish blue suffused with greyish brown except S2-3, which are a sky blue (the saddle). The basal ring on S1 is distinctively yellow (anterior to saddle). In *A imperator*, this region is yellow only in fresh individuals, while in *A ephippiger* it is brown. With the exception of the saddle, which is usually absent in females, there is less colour difference between females of this species than there is in *A. imperator*. Specimens with a more brownish abdominal coloration can be confused with *A. ephippiger* (although this is generally a smaller species) while specimens which are more bluish can be confused with *A. imperator*. Females resemble males more than in *A. imperator.* Wings are clear in males but have brownish markings on females, which differ from those of *A. imperator* females in that these markings are found between the pterostigma and the node.

On close inspection. The short male inferior anal appendage (Figs. 36c-d) is less than $^{1}/_{5}$ of the length of the superior appendages, and teeth-like structures found on the upper side. Superior anal appendages bear an apical point with a small spine at the tip. Females can be distinguished from those of other *Anax* specimens by the occurrence of a pair of tubercles in the occipital region, behind the eyes (Fig. 39b).

Behaviour. This species flies slightly less rapidly than *A. imperator*. Males of *A. parthenope* are occasionally harassed by those of *A. imperator* for territory, thus have to move from one area to another. They have been observed to dive into water following a period of vigerous flight activity. This is possibly a thermoregulatory strategy. *Anax parthenope* flies keeping its abdomen straight. Oviposition can either occur in tandem (Fig. 38b) or by the unaccompanied female. Eggs have be observed by the author to be deposited either within floating vegetation and debris, or in very shallow muddy deposits in rainwater pools.

[37] This could imply that the larvae are surviving through some form of aestivation strategy, though more research needs to be carried out to confirm this theory.

Figures 38a-d: **a**: *Anax parthenope* male in flight; **b**: *A. parthenope* tandem oviposition; **c**: *A. parthenope* larva; **d**: *A. parthenope* exuvia.

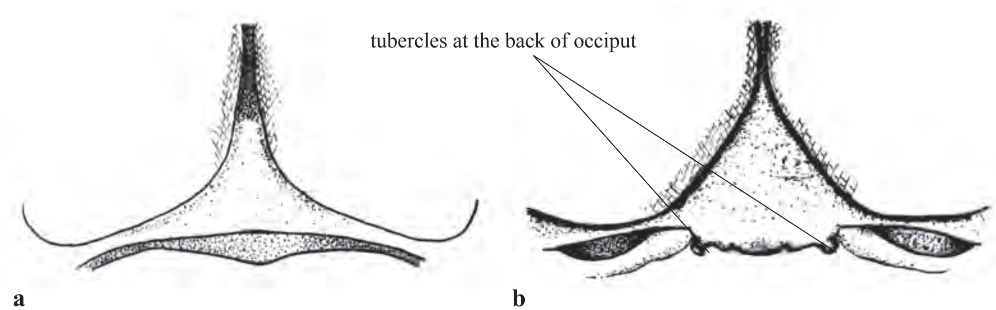


Figure 39a-b: Occiput of *Anax* females (dorsal view). **a**: *Anax imperator*; **b**: *A. parthenope.*

OCCURRENCE: Habitat. *Anax parthenope* frequents ponds and lakes and similar large standing water bodies. The species has also been observed to oviposit in brackish water at il-Ballut, M'Xlokk, and at Simar Nature Reserve, but no exuviae were ever collected.

Local distribution. The species is found across a large part of the islands.

Global distribution. *Anax parthenope* occurs in most of Central Europe. It is absent from the northern Balkans, Britain, northern France, Benelux, and Scandinavia. Its range extends to North Africa, the Middle East, Russia, China and Japan (Askew, 2004; Boudot, *et al.*, 2009).

Flight season. Locally recorded from February till November, but occurs in greater numbers in Summer and Autumn. Shorter flight periods are recorded in northern countries. Similar flight periods are observed in northern Africa.

Larval stages. The elliptical eggs can be parasitized by parasitoid wasps of the family Mymaridae (Shimura, 2003, who observed this phenomenon occurring in the Japanese subspecies *julius*). No local records found to date.

Larvae (Figs. 38c-d). Very similar to that of *A. imperator* in size, morphology and behaviour. Distinguished from *A. imperator* by the lateral spines which are found on S9 in both sexes and the male projection (Fig. 77b) which is shorter ($^1/_3$ the size of the cerci) than in *A. imperator* (Fig. 77c).

***Anax ephippiger* (Burmeister, 1839)**
(Fig. 40)

Vagrant Emperor
Sultan Dehbi[38]

Status: Scarce but widespread.

Bl: 61 - 70 mm.
Hw: 43 - 48 mm.

IDENTIFICATION: General. This is the smallest locally recorded *Anax*. Both sexes are of a sandy light brown coloration. Males also have the conspicuous bright blue saddle on S2-3.

In the field. The blue saddle in males does not cover the sides of S2-3 (Fig. 40a). The saddle is less intense and evident in female (Fig. 40a) and younger males. Eyes are brown above and yellow underneath. The head shows no blue colouring on the eyes and frons as in other *Anax spp*. Two black bars on the frons also distinguish it from other *Anax* species. The abdomen is more slender, and brown with black dorsal band, which widens on S8-10. Pale brown spots occur on these segments.

On close inspection. Distinguished from *A. parthenope* in that the cells between the cubital and anal veins appear more irregularly disposed. Male inferior appendage (Figs. 36e-f) ¼ of the length of the superior appendages, triangular in shape and with more teeth like structures on upper surface than in *A. parthenope*. Male superior appendages (Figs. 36e-f) tapered and pointed. Female appendages are broad and pointed, rather similar to male appendages. Female back of occiput smooth with no tubercles.

[38] The name "Mazzarell Dehbi" (translated as golden dragonfly), is used by hunters and farmers frequenting the Żurrieq and Wied Babu areas, where the species is sighted. The word "Sultan", or king, has been added to distinguish this species as an aeshnid.

Behaviour. *Anax ephippiger* shows strong migratory tendencies. It is in fact described by Corbet (2004) as "*... a paneremian migrant ... highly specialized for desert conditions...*". Migration begins from early post-teneral stage (Corbet, 2004). This accounts for the large range of records of this species across different countries. Large groups of this species are periodically recorded in specific sites on the islands. The species has also been observed locally to roost in strategically chosen places during the evening (Ebejer *et al*., 2007). Oviposition occurs in tandem. Females have been observed to drop eggs into the water from a submerged abdomen, and even washing eggs off the tip of the abdomen (Corbet, 2004).

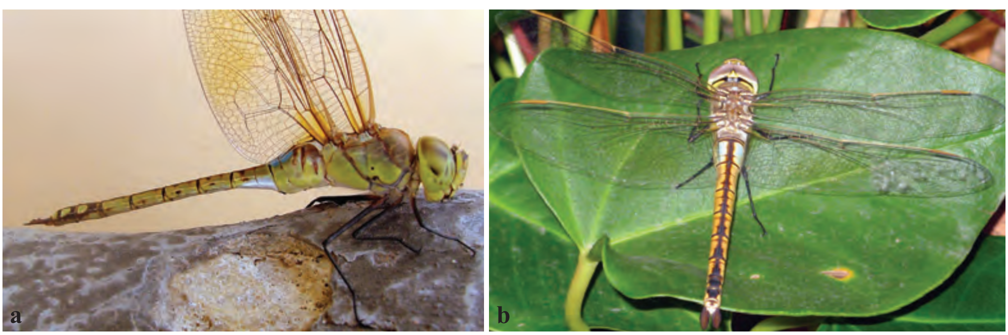
OCCURRENCE: Habitat. It breeds in small standing water bodies, sometimes of a temporary nature, even in brackish water.

Local distribution. The species has been locally recorded in many valleys in Malta such as Wied iI-Għasel, Mosta and Wied Babu, Żurrieq and tandem pairs have been observed in different locations by Ebejer and by the author. Sightings of large groups of individuals across the islands are not uncommon especially in Autumn (Ebejer *et al*., 2008).

Global distribution. The main distribution range of this species spans mostly across arid regions of Africa, the Middle East and Asia to Pakistan. Due to its migratory nature however, it breeds sporadically in southern Europe. Specimens have been captured as far north as Ireland (Nelson *et al.*, 2000), and even in Iceland (Corbet, 2004).

Flight season. Locally recorded from February to October. There have been many records in both Spring and in Autumn. Shorter flight periods in northern countries. Occurs all year round in other Mediterranean countries.

Larval stages. Larvae are similar to, though smaller than, the previously mentioned *Anax* species (exuviae 76 - 84 mm, Gerken & Sternberg, 1999). Distinguished from other *Anax* by: (i) the back of eyes, which, when seen dorsally, line up into a straight line, or at most a "V" shape pointing towards front part of the head (in other *Anax*, back of eyes line up in a "V" shape pointing to the back of the head) (Doucet, 2010) (Fig. 76b); (ii) and the male projection at the base of epiproct not clearly differentiated and apically acute (Askew, 2004) (Fig. 77d). According to Corbet (2004) its life cycle can take between two to three months and even less. The short duration of the development of these larvae is typical of species with a migratory nature. Oviposition has been observed locally, local breeding is highly probable, but no exuviae have ever been found.



Figures 40a-b: *Anax ephippiger*. **a**: male (lateral view); **b**: female (dorsal view).

Family Libellulidae

This is the largest anisopteran family. Libellulids are the predominant anisopterans in most parts of the world, and include the most evolved species of odonates. Species are typically small to large in size, non-metallic in colour. Most species tend to make rapid forays in pursuit of prey from a perch, this often being a twig or stem. Hindwings are sometimes very broad at the base, particularly in migratory species. Forewing and hindwing venations vary considerably, unlike all families mentioned so far. Their abdomen is short and in some cases (e.g. *Crocothemis*) broad and triangular in cross section.

Mature males are generally more colourful and conspicuous than females. Metallic colours are scarce, and not found in local species. Teneral males resemble females and lack pruinosity, while mature females can at times resemble males as they develop some pruinosity. When at rest, they are often seen with wings drooping and body either horizontal, or raised upwards during periods of hot sun (in the "obelisk" position), for minimum exposure to the sun thus preventing overheating (see section entitled "adult life functions" pg.17). The female ovipositor is vestigial, and ovipositing is mainly of the exophytic type. Eggs are mostly spherical in shape. Libellulids are generally associated with stagnant or slow moving waters. Some species have migratory habits. Larvae usually display a number of behavior types. They are distinguishable from the number of setae on the labial mask, as well as from the presence of absence or dorsal spines (see tables 21-22). Labial mask is rounded and lines the contours of the face (Fig. 74b).

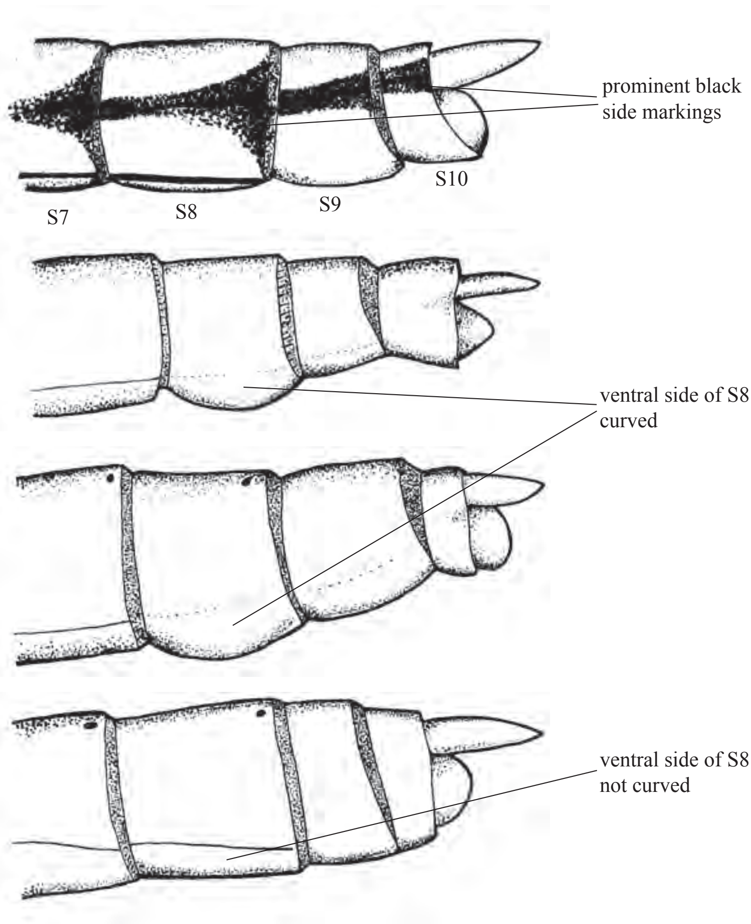
In the Maltese Islands this family is represented by twelve species accomodated in six genera. These are the genus *Orthetrum* with six species, the genus *Sympetrum* with two species and one species in each of the genera, *Crocothemis*, *Trithemis*, *Selysiothemis*, and *Pantala*. Features of these six genera are included in tables 5a and 5b.

The genus *Orthetrum* Newman, 1833

The overall body colour of species belonging to this genus varies but it is never bright red. Females and young males are usually yellowish green to brownish. Adult males develop pruinosity over part or all of the abdomen, and some even on the thorax. Old females often develop some pruinosity, though never as much as males. The discoidal cell is with crossvein. One to two rows of cells occur before rspl. The post discoidal field (trigonal space) has a row of three cells basally adjacent to discoidal cell. Hindwings have no coloured markings at base.

Larvae are usually hiders, or burrowers, or both. They are distinguishable from the number of setae on the labial mask, as well as from the presence of absence or dorsal spines (see table 20).

Six species of this genus have been recorded on the Maltese Islands. Table 8 distinguishes between these species.



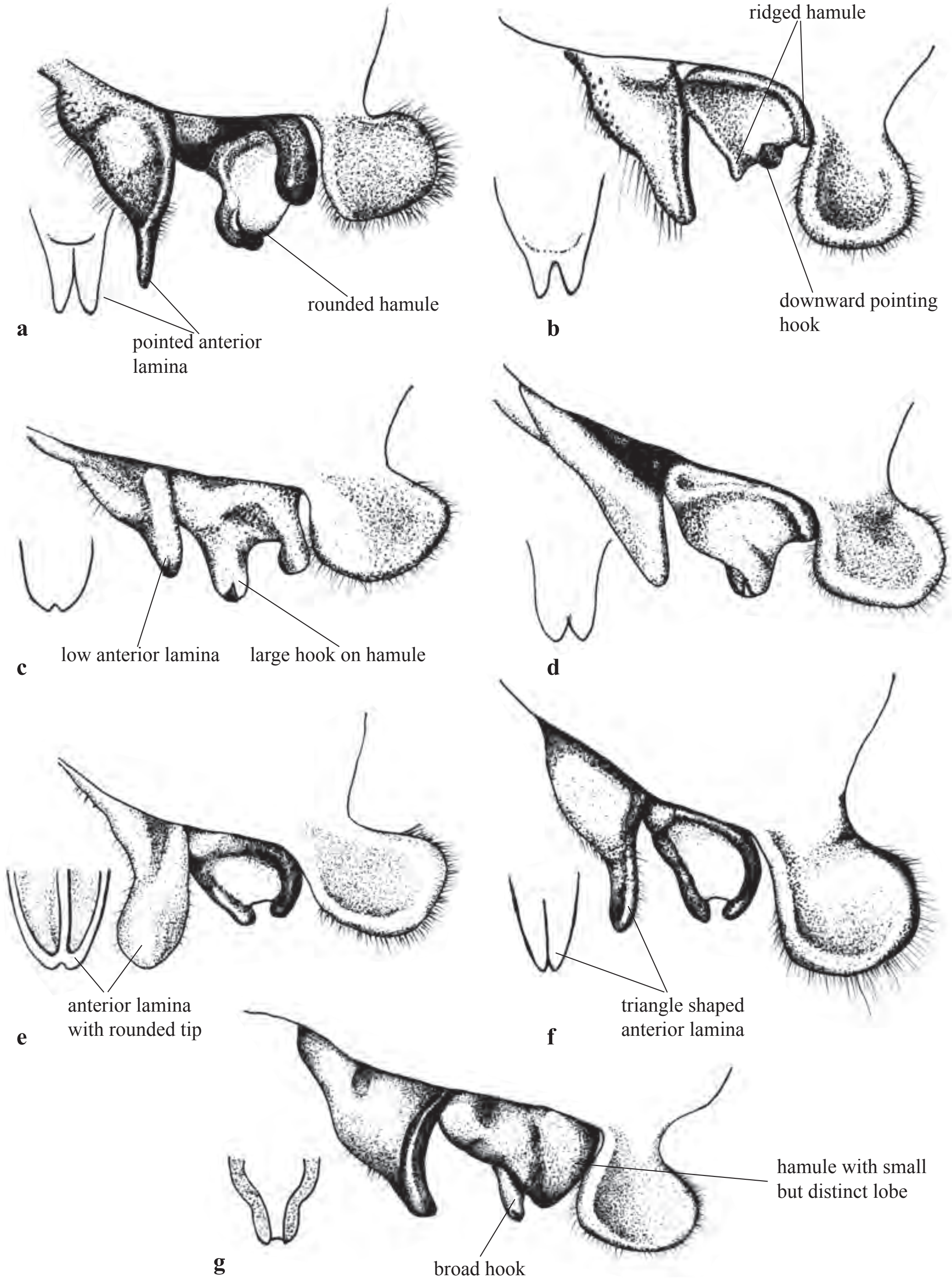
Figures 41a-d: *Orthetrum* female hindmost segments. **a**: *O. cancellatum*; **b**: *O. coerulescens*; **c**: *O. brunneum*; **d**: *O. nitidinerve*.

Table 8. Features that distinguish between *Orthetrum* species inhabiting the Maltese Islands.

Feature	*O. cancellatum*	*O. trinacria*	*O. coerulescens anceps*	*O. brunneum*	*O. nitidinerve*	*O.chrysostigma*
Distinctive characters	S10 dorsally yellow and brown, and mid dorsal abdominal carina on central abdominal segments yellow with only the spikules dark. Superior anal appendages black in both sexes	S2 + 3 swollen and three times as thick as other segments and at least four times as deep as S4	Face brownish, never bluish	Face bluish, widespread distribution	Vein R1 yellowish to the level of the node	Thorax with one pale dark bordered stripe immediately behind humeral suture
Body size	Larger (44 - 55 mm)	Larger (5.7 - 6.0 mm never > 43 mm)	Medium size: 36 - 40 mm	Larger, seldom < 45 mm	Length seldom < 4.6 - 4.9 mm	Medium/ large size - smaller than *O. nitidinerve*
Wings	Light costal veins	Row of cells between IR3 and rspl veins partially double	Clear. One row of cells above rspl in most wings	Vein R1 black. females in profile with ventral edge slightly convex. Row of cells between veins IR3 and rspl extensively (at least four cells) doubled	Post costal part of costa very pale. 2 rows of cells in rspl	½ rows under rspl
Pterostigma	Blackish and smallish	Large and yellowish to brown	Large (up to 3.0 mm long) and yellow	Smallish (2.5 - 3.0 mm long not longer than the breath of the abdomen) yellow to reddish-brown	Large (4 - 5 mm) and ochre	Medium sized and yellowish
Membranule	Pale greyish	Medium greyish	Intermediate shade	Pale (whitish)	Pale	Dark with small yellow (infuscate) patch in adjacent hindwing

Table 8 (cont.). Features that distinguish between *Orthetrum* species inhabiting the Maltese Islands.

Feature	*O. cancellatum*	*O. trinacria*	*O. coerulescens anceps*	*O. brunneum*	*O. nitidinerve*	*O.chrysostigma*
Abdomen	With two black longitudinal stripes. In females and immature males patterned on S3 - 8 with broad black lateral lines (Fig. 41a) which curve inwards above lateral carina to isolate yellow spots	Cylindrical and thin – at least as long as hindwing. When not pruinose black with pale streaks or rings	Thin dorsal black line with a pair of black dots per segment which can fuse as a cross bar with central line. Ventral side of S8 curved (Fig. 41b)	Shorter than hindwing somewhat compressed dorsoventrally and triquetral. Broad black lateral lines absent. Thin dorsal black line with pair of black dots per segment never fuse with central line. S2 and S8 maximally twice as deep as S4. Ventral side of S8 curved (Fig. 41c)	Similar to *O. brunneum*, but female S8 in profile with the ventral edge straight (Fig. 41d)	Similar to *O. brunneum* an *O. nitidinerve* but waisted
Male secondary genitalia	As in Fig. 42a	As in Fig. 42b	Anterior lamina triangular in profile pointed and slightly longer than in other species	Inferior lamina in profile much shorter then the conspicuously bilobed hamule	As in Fig. 42f	As in Fig. 42g



Figures 42a-g: *Orthetrum* male secondary genitalia lateral view with frontal view of laminar plate. **a**: *O. cancellatum*; **b**: *O. trinacria*; **c**: *O. brunneum*; **d**: *O. nitidinerve*; **e**: *O. coerulescens coerulescens*; **f**: *O. coerulescens anceps*; **g**: *O. chrysostigma*.

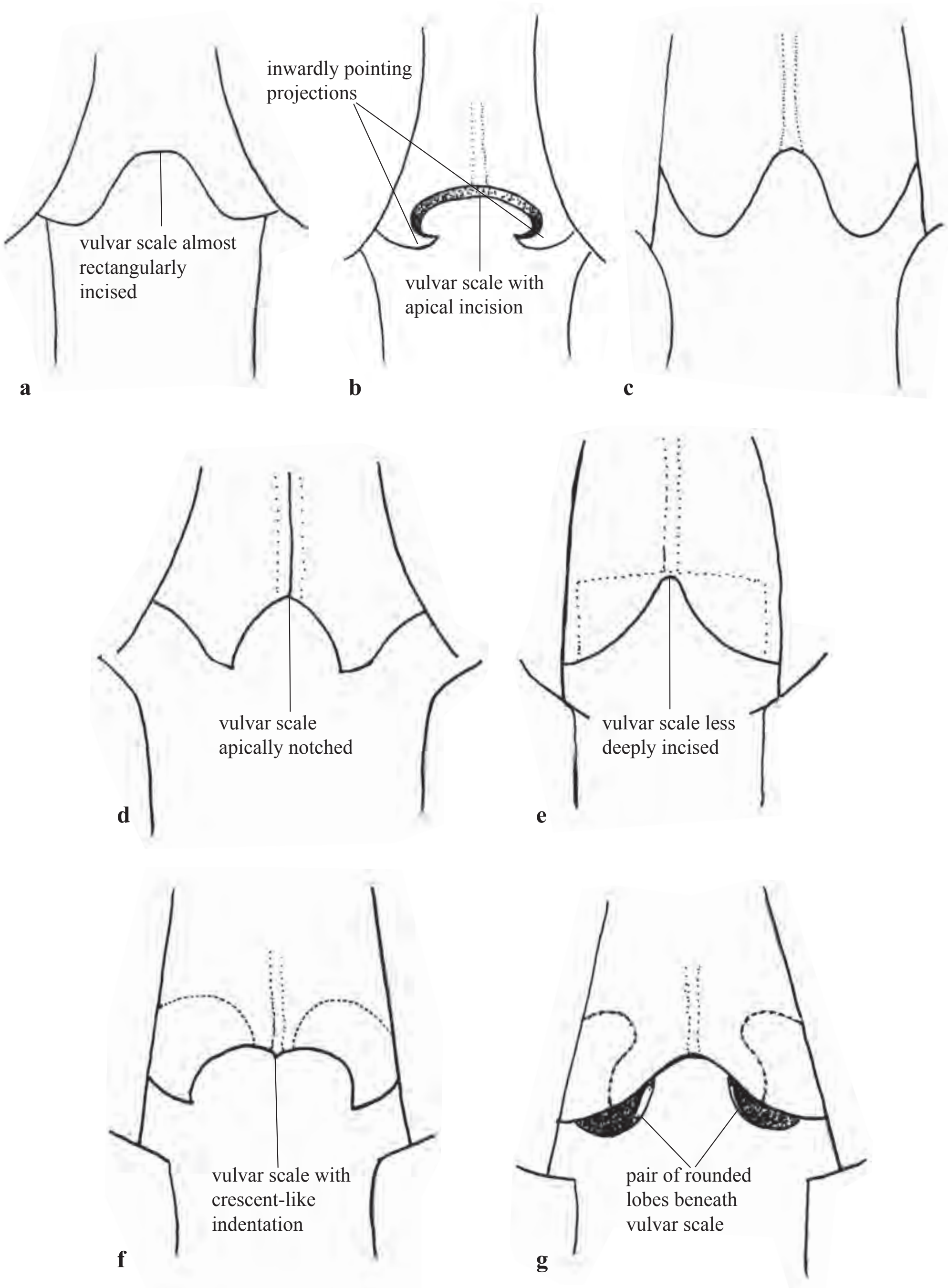


Figure 43a-g: *Orthetrum female* vulvar scales ventral view (modified after ASKEW, 2004). **a**: *O. cancellatum*; **b**: *O. trinacria*; **c**: *O. brunneum*; **d**: *O. nitidinerve*; **e**: *O. coerulescens coerulescens*; **f**: *O. coerulescens anceps*; **g**: *O. chrysostigma*.

***Orthetrum cancellatum* (Linnaeus, 1758)**
(Figs. 44a-b & 45a-c)

Black-tailed Skimmer
Kaħlani tal-Faxx

Status: Scarce and localized.

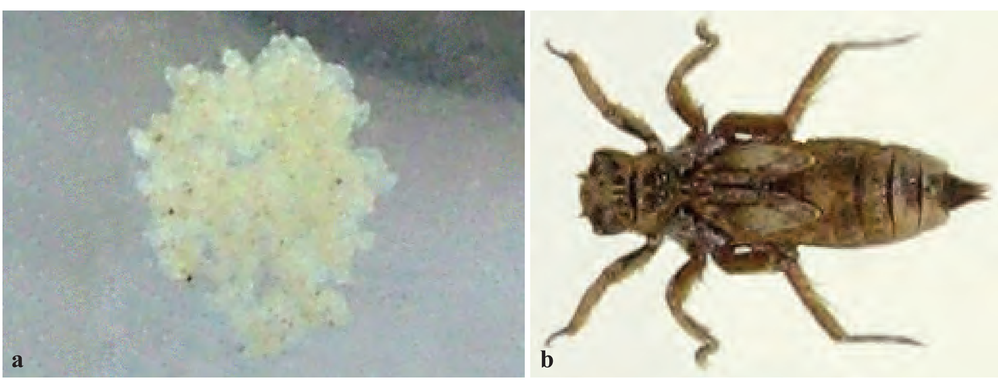
Bl: 44 - 50 mm.
Hw: 35 - 41 mm.

IDENTIFICATION: General. A fast largish species with characteristic, festooned lateral stripes on the abdomen which is broad and black tipped. The species used to be a more familiar sight in the Maltese countryside up until the early 1990's.

In the field. In males (Fig. 45a) and some mature females (Fig. 45c), the anterior abdominal segments are brown and posterior ones (S (6-) 8-10), black (Dijkstra & Lewington, 2006). The rest of the abdomen is a pruinous powdery blue colour. Females (Fig. 45b) and young males are yellow with two thick lengthwise black stripes. In both sexes, crescent like yellowish orange spots occur at the sides of each abdominal segment, which become more evident in pruinous males. Wings are clear, and the pterostigma is black. The legs are also black.

On close inspection. When viewed from behind, the anterior lamina in the male secondary genitalia (Fig. 42a) is large, rounded and deeply notched with a "V" - shape, and with long hairs on its anterior face. In males, the hamule has a very large and rounded head. The female vulvar scale (Fig. 43a) is almost rectangularly incised (Askew, 2004).

Behaviour. Males often perch on the ground. They are territorial and guard the ovipositing females in their territory. Establishment of territories varies according to the orientation of the sun (Degabriele,1992). Moreover, males often attach themselves to one territorial site and return to it following bouts of inclement weather (Corbet, 2004). Copulation lasts around 15-20 minutes (d'Aguilar *et al*., 1985; Miller, 1995). Females have been recorded to oviposit in seawater (Cilia, 1972).



Figures 44a-b: *Orthetrum cancellatum* pre imaginal stages. **a**: eggs; **b**: larva.

OCCURENCE: Habitat. The species frequents stagnant ponds, of often brackish water, though no such records exist from the Maltese Islands.

Local distribution. Recent observations by the author and others (Balzan, 2012) have shown that numbers of this species have declined since the 1990's. More research is required to determine the reasons of this decline. All recent records of this species come from the northern part of the islands.

Global distribution. *Orthetrum cancellatum* is common throughout Europe, North Africa and the Middle East, up to Mongolia (Dijkstra & Lewington, 2006).

Flight season. Locally recorded from May to October, with most records occurring in Summer. Similar occurrence in the Mediterranean Region.

Larval stages. Eggs (Fig. 44a) are pale yellow when laid. Larvae (Fig. 44b) are large (final instar larva 21 - 29 mm, Doucet, 2010) and robust, hairy and stockier than those of *Sympetrum* and *Crocothemis* (Carchini, 1983). The head (Fig. 78) is rectangular in shape. The labial mask is almost straight with slight indentations (Fig. 79a). Setae on labial palp and prementum described in table 20.Well developed lateral spines on S8 - 9 (Fig. 81a). Legs are stout and do not extend beyond tip of abdomen when outstretched. Epiproct is twice longer than broad (Fig. 80a).

They roam pond beds in search of prey. They tend to hide within the pond bed, burrowing in the pond sediment, covering themselves with pond debris which attaches to the setae on their body.

Figures 45a-c: *Orthetrum cancellatum*. **a**: male; **b**: mature female; **c**: old female.

Orthetrum trinacria **(Selys, 1841)**
(Figs. 46a-c & 47)

Long Skimmer
Kaħlani ta' Sarraflu

Status: Rather common and widespread.

Bl: 51 - 67 mm.
Hw: 34 - 38 mm.

IDENTIFICATION: General. This is the largest *Orthetrum* species occurring locally. The perched bluish black males (Fig. 46a) are becoming a familiar site in valley areas with standing freshwater bodies.

In the field. The ground colour in females (Fig. 46b) and young males is yellowish or olivaceous. It becomes darker in colour (dark bluish to almost black - as compared to other *Orthetrum*, which are of a pale powdery blue coloration) and basally covered by a pruinescence in mature males and old females (Fig. 46c). The main typical distinguishing feature of this species is the abdomen, which is longer than the hindwings (in all local *Orthetrum* species except *O. cancellatum* it is shorter) and is waisted, becoming very long and slender in both sexes. Wings are black, and pterostigma (about 4 mm long) yellowish brown. The legs are equipped with rather longer spines than those found in other *Orthetrum* species.

On close inspection. The row of cells between IR_3 and rspl veins is partially double. The anterior lamina of male accessory genitalia has long hairs on its anterior face, and a bi-lobed apex. The hamule in males has a downward pointing hook between two ridges (Fig. 42b). The male superior anal appendage twice as long as inferior. Female appendages are almost three times as long as S10. The apical incision of the female vulvar scale (Fig. 43b) is broad but shallow and with a pair of inwardly-pointing projections (Askew, 2004).

Behaviour. Its hawking flight resembles that of an aeshnid. It can perch both on the ground as well as on tree branches like aeshnids. It tends to be an aggressive species, and male specimens have been observed by the author to ward off smaller species of libellulids (e.g. *Sympetrum*, *Crocothemis* and *Trithemis*), from its territory. May be found away from water (d' Aguilar *et al*., 1985). It has also been observed to prey on other smaller dragonfly species, and to attack other large insects such as butterflies and wasps. *Orthetrum trinacria* has been observed by the author to oviposit in tandem.

OCCURENCE: Habitat. A species which is associated mostly with reservoirs and other similar large bodies of water.

Local distribution. First recorded on the Maltese Islands in 2003 at Għadira ta' Sarraflu, Kerċem, Gozo (Ebejer *et al*., 2008). Since then, more specimens have been sighted and captured from different locations across the islands. Larvae and exuviae (Fig. 47) were also locally collected. Recent observations by the author and Balzan (2012) show that the species has well established itself locally.

Figures 46a-c: *Orthetrum trinacria.* **a**: male; **b**: mature female; **c**: old female.

Global distribution. *Orthetrum trinacria* is a predominantly African species. This species ranges from Morocco to Sudan, Egypt to the Middle East. In Europe, it has only been recorded in southern Spain, Sardinia, and in Sicily, from where it was originally described (Askew, 2004; Dijkstra & Lewington, 2006).

Flight season. Locally from May to October. Similar occurrence in the Mediterranean Region.

Larval stages. Larvae are similar in appearance and behaviour to those of *O. cancellatum*, however are somewhat longer and with longer legs and a longer caudal pyramid than *O. cancellatum* with epiproct 2.5 times longer than broad (Fig. 80b) (Carchini, 1983; Gerken & Sternberg, 1999).

Figure 47: *Orthetrum trinacria* exuvia.

Orthetrum brunneum (Fonscolombe, 1837)

(Figs. 48a-b)

Southern Skimmer
Kaħlani Rari

Status: Very rare and localised.

Bl: 41 - 49 mm.
Hw: 33 - 37 mm.

IDENTIFICATION: General. A rather robust species, larger and heavier than *O. coerulescens*.

In the field. Adult males (Fig. 48a) have a thorax and abdomen which are completely blue. Females (Fig. 48b) and young males are brownish to a dull olive green. Both sexes distinctively lack body markings, with only a thin black line running down the abdomen when not pruinose. Slightly larger than *O. coerulescens anceps* and slightly smaller than *O. cancellatum*. Rather hard to separate from *O. coerulescens anceps* unless closely examining a specimen, however distinguished by: (i) the white to pale blue face in males (in *O. coerulescens anceps* it is brownish); (ii) the male thorax, which is plain and without antehumeral stripes when not pruinose; (iii) the pterostigma, which is short and reddish brown when mature; and (iv) the abdomen which, when not pruinose, has a pair of spots which flank the mid-line and never fuse with it (as in *O. coerulescens anceps*).

On close inspection. Can be further distinguished from *O. coerulesens anceps* by: (i) the space between the IR_3 veins and the rspl in the wing being occupied by two rows of cells (4+ cell couplings, Fig. 49a) in more than one of the wings; and (ii) the large hook on the hamule, extending beyond the rather low lamina (Fig. 42c). Female vulvar scale as in figure 43c.

Behaviour. *Orthetrum brunneum* perches on jutting objects including rocks and stones next to running water bodies. Males are territorial, and after copulation, guide the females to oviposit in their territory, whilst guarding them against the approaches of other males. Mating and oviposition as in *O. cancellatum*.

OCCURENCE: Habitat. The species usually frequents streams, springs and canals with a slow rate of flow. The scarceness of such habitats in the islands, and perhaps lack of adaptability of the species may have contributed to this species being so rare on the islands.

Local distribution. It has mostly been recorded in the western parts of Malta, where freshwater streams are more abundant. Most records are pre 2000. The most recent local records of this species date from 2001 (Ebejer *et al*., 2008).

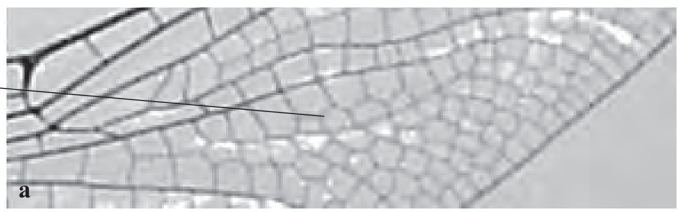
Global distribution. *Orthetrum brunneum* is common and widespread throughout Mediterranean Europe, though less common in North Africa. Its range extends to Asia as far as Mongolia with populations have also been expanding northwards since 1990's (Dijkstra & Lewington, 2006; Boudot *et al*., 2009).

Flight season. Local records from June - October. Similar occurrence in the Mediterranean Region.

Larval stages. Larvae are smaller, and more compact and hairy than those of *O. cancellatum*. Setae on labial palp and prementum described in tables 18 and 19. Dorsal spines and lateral spines on S8 - 9 often absent (Fig. 81d). Epiproct is 1.5 times longer than broad (Fig. 80d). Larvae also tend to cover themselves in mud particles and bury themselves in mud in order to ambush its prey. Breeding has never been confirmed locally.

Figures 48a-b: *Orthetrum brunneum.* **a**: male; **b**: female.

Space between IR_3 and rspl occupied by two rows of cells (4 cell doublings) on almost all wings.



Space between IR_3 and rspl occupied by one row of cells (1 cell doubling) a few couplings may be present on only a few wings.

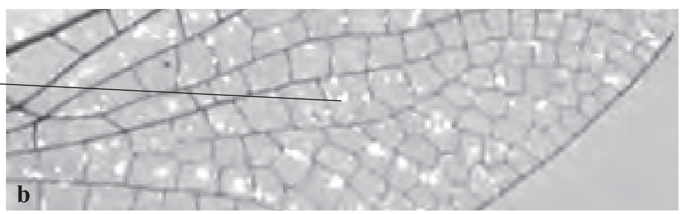


Figure 49a-b: Wing differences in: **a**: *O. brunneum*; **b**: *O coerulescens*.

Orthetrum coerulescens
anceps (Schneider, 1845)
(Figs. 50a-c)

Keeled Skimmer
Kaħlani Żgħir

Status: Rather common and widespread.

Bl: 36 - 45 mm.
Hw: 28 - 33 mm.

IDENTIFICATION: General. Arguably the most locally common *Orthetrum*. A medium-sized, attractive species, which has become more common in the Maltese Islands. Previously referred to as *O. anceps* (syn. *O. ramburii*, Selys, 1848) and treated in the past as a separate species from *O. coerulescens*, it is nowadays largely considered a subspecies of *O. coerulescens* because of: (i) the integration of distribution ranges of ssp. *coerulescens* and ssp. *anceps* throughout the Mediterranean Region, as well as in some eastern European countries (ssp. *coerulescens* has a typical distribution range that spans more to the north as compared to that of ssp. *anceps*) and (ii) because of the intermediate forms found in the region of overlap (Dijkstra & Lewington, 2006; Dijkstra & Kalkman, 2012). Close inspection is required to identify as similar species occur in the islands.

In the field. This species is smaller and more slender than *O. brunneum,* with a narrower abdomen. While in ssp. *coerulescens*, the thorax is brown and with very reduced pruinosity, ssp. *anceps*, males (Fig. 50a) have both the thorax and abdomen covered in blue, making them difficult to separate from *O. brunneum*. Intermediate forms occur locally however, and males with a non-pruinose thorax (Fig. 50c) are commonly observed. Nonetheless, *O. coerulescens anceps* does show the following distinct features which are not present on *O. brunneum*: (i) the two prominent antehumeral thoracic stripes visible in females and young non-pruinose males (these remain visible in pruinose males of ssp. *coerulescens*); (ii) the pterostigma, which is yellowish brown and (iii) the face, which in both ssp., is always brown and never blue. Females (Fig. 50b-c) and young males are typically ochre yellow with black markings. They can be confused with *Sympetrum* females, however these can be distinguished from the presence of the antehumeral stripes, absent in *Sympetrum*.

On close inspection. Wings are clear, and the space between the IR_3 veins and rspl is occupied mostly by one row of cells (Fig. 49b) as compared to *O. brunneum* which typically has 6-7 couplings in more than one wing. The anterior lamina in the male secondary genitalia has a rounded tip in ssp. *coerulescens*, and a triangular tip in ssp. *anceps* (Fig. 42d-e) (Dijkstra & Lewington, 2006). This is a typical distinguishing feature between specimens of the two subspecies, but also distinguishes *O. coerulescens* from *O. brunneum*. The vulvar scale in females of ssp. *coerulescens* (Fig. 43e) is apically notched, while that of the ssp. *anceps* (Fig. 43f) is less sharply incised (Askew, 2004).

OCCURENCE: Habitat. The species is observed by the author and by Balzan, (2012) to exclusively frequent standing waters and slow moving streams which are shaded by trees or tall vegetation.

Local distribution. All records refer to the presence of ssp. *anceps*. *O. coerulescens anceps* is mostly found in the northwestern parts of the islands, particularly in valleys, but has also been recorded from other areas. Recent fieldwork observations by the author in Autumn 2012 and by Balzan (2012) show that the species is becoming rather widespread.

Behaviour. Perches on vegetation, unlike *O. brunneum* and *O. cancellatum*.

Global distribution. The species is common in most of Europe, North Africa, Middle East and Asia to northern India (Askew, 2004; Boudot *et al*., 2009).

Flight season. Locally from May - October; more abundant in Spring. Similar occurrence in the Mediterranean Region.

Larval stages. Similar to the previously mentioned *Orthetrum* species. Setae on labial palp and prementum (Fig. 79c) are described in tables 18 and 19. Larvae grow smaller in size than *O. cancellatum* an *O. trinacria* (Final instar 17 - 23 mm, Cham, 2007). Eyes are very small. Dorsal spines present on all segments but very small on S7 and absent on S8 (Fig. 81c). Epiproct as in *O. brunneum* (Fig. 80c).

Figures 50a-c: *Orthetrum coerulescens anceps*. **a**: male; **b**: female; **c**: mating pair.

***Orthetrum nitidinerve* (Sélys, 1841)**
(Figs. 51a-b)

Yellow-veined Skimmer
Kaħlani tal-vina Safra[39]

Status: Single record.

Bl: 41 - 50 mm.
Hw: 31 - 38 mm.

IDENTIFICATION: General. A rather large *Orthetrum* with big ochre pterostigmas and a distinctive, golden radial veins (Fig. 51a).

In the field. Very similar to *O. brunneum* and *O. coerulescens anceps*, with adult males being all blue and females (Fig. 51b) and young males brownish and with very little body markings as in *O. brunneum*. It is distinguished from these species by: (i) the yellowish radial vein and the costa between node and pterostigma; (ii) the longish (4-5 mm) ochre pterostigma (larger and lighter than in *O. brunneum*); (iii) the pruinosity, which is a slightly lighter shade of blue than in *O. brunneum*.

On close inspection. Male anterior lamina (Fig. 42d) is broad and has a slight notch on tip and with few hairs on anterior face. S8 in females does not expand ventrally as in other *Orthetrum* (Fig. 41d). Female vulvar scale (Fig. 43d) with a crescent-like indentation.

OCCURRENCE: Habitat. Standing and moving waters. Frequents arid habitats.

Local distribution. A few specimens recorded in 2008 in the North part of Malta (Sciberras *et al.*, 2010). More records may be expected.

Global distribution. *Orthetrum nitidinerve* originates from North West Africa. It extends its range northwards to southern Spain and France, Sicily, Sardinia and southern Italy, where it is rare and with smaller numbers of populations (Boudot *et al.*, 2009). In recent years its population range has decreased and is the only locally occurring species given the status of "vulnerable" by the European Red list of Dragonflies (Kalkman *et al.*, 2010).

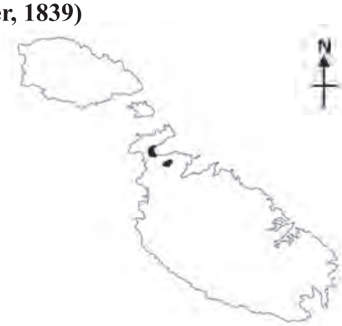
Flight season. April - October (Dijkstra & Lewington, 2006).

Larval stages. Larvae have the following distinctive features: (i) mid dorsal abdominal spines absent but with a tuft of setae on margin of tergite 4-5 and (ii) prementum with two rows of 15 -16 short inner setae and one long setae near exterior premental margin (Gerken & Sternberg, 1999). Larval biology is not well known but expected to be similar to that of other *Orthetrum*. No local records of larvae exist to date.

[39] No Maltese vernacular name for this species exists or could be confirmed to date. This was coined by the author in the style of the other names given to other species.

Figures 51a-b: *Orthetrum nitidinerve.* **a**: male showing distinctive golden radial veins; **b**: mating pair.

Orthetrum chrysostigma (Burmeister, 1839)
(Fig. 52)



Epaulet Skimmer
Kaħlani tal-Penz

Status: Single record.

Bl: 39 - 48 mm.
Hw: 27 - 32 mm.

IDENTIFICATION: General. A species which is similar to the other *Orthetrum* found locally, but distinguished by the epaulet (or Maltese "Penz") or white stripe on each side (Fig. 52).

In the field. Like *Orthetrum brunneum* and *O. coerulescens anceps*, males become fully pruinose throughout their body, while females and young males are a yellowish brown. The white side stripe is different from the pale antehumeral stripe of *O. coerulescens anceps* and whiter. Distinctive features for this species include: (i) the rather slender and waisted abdomen; (ii) the mid-dorsal whitish stripe on the thorax at the base of each wing and (iii) the sooty membranules with yellow patch where the wing connects with the thorax. In all other similar *Orthetrum* species, membranules are white and no yellow patch occurs at the hindwing base.

On close inspection. In males, anterior lamina is long and triangular. The hook on hamule is broad and dwarfs the posterior lobe (Fig. 42g). The female vulvar scale has a pair of rounded lobes beneath (Fig. 43g).

Behaviour. The species never perches in the obelisk position.

OCCURENCE: Habitat. Larger standing or moving water bodies in open landscapes, often with no surrounding vegetation.

Local distribution. Recorded in 2010 (Gauci & Sciberras, 2010) from the Mellieħa - Selmun area.

Global distribution. *Orthetrum chrysostigma* is a southern species known from Tunisia, southern Spain and Turkey, adjacent Greek Islands and the Canaries. It is likely to expand north (Dijkstra & Lewington, 2006).

Flight season. April - late August. May be on the wing for longer period in northern Africa (Dijkstra & Lewington, 2006)

Larval stages. Biology of larvae is not well known but believed to be similar to other *Orthetrum* species. No local larval records exist.

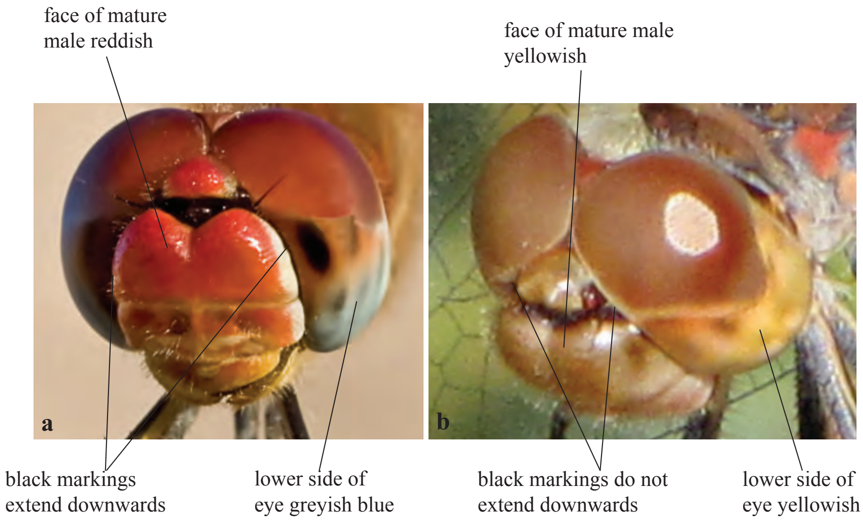
Figure 52: *Orthetrum chrysostigma* mating pair. Both sexes show the distinctive white epaulet on the side of the thorax.

The genus *Sympetrum* Newman, 1833

Slender and medium sized species, with red to brownish red males and yellowish females. Both sexes may have black markings on thorax, abdomen and legs. Distinctive features include: (i) the prothorax with well developed raised posterior lobe; (ii) wings with 6 ½ - 8 ½ antenodal cross veins; (iii) the discoidal field on the forewing which has two to four cells (typically three) and which narrows towards the wing base; (iv) the forewing triangle with two cells, and the subtriangle with three cells; and (v) the abdomen**,** which is always red. Male *Sympetrum* specimens have been observed by the author to repeatedly immerse their abdomens in water. Corbet, (2004) and Corbet & Brooks, (2008) also report this and similar behaviour in other species, and classify it as having a thermoregulatory function. The authors also report that this behaviour can sometimes be confused with exophytic oviposition behaviour. Two *Sympetrum* species are recorded from the Maltese Islands and table 9 provides distinguishing characteristics between them.

Table 9. Features that distinguish between *Sympetrum* species occurring in the Maltese Islands.

Feature	*S. fonscolombii*	*S. striolatum*
Thorax	Not as follows	Sides with conspicuous sutural stripes
Wing veins	Many in basal thirds of wings reddish in males and yellowish in females. Amber patch present on hindwing	Not as before
Pterostigma	Pale yellow with contrasting broad black borders	Brownish and darker
Hindwing	With prominent amber patch at base invades one or several cells of foot shaped anal loop. This area often not extending to discoidal cell	No amber patch present. Wings clear.
Abdomen	Not clubbed and with lateral marks less prominent	Weakly clubbed and with lateral marks more prominent
Secondary male genitalia	Not as follows (Fig. 55a)	Anterior process of hamule longer than posterior process and with small terminal hook (Fig. 55b)
Female vulvar scale	Deeply incised and bilobed (Fig. 57a)	More pressed towards abdomen, Prominent and not strongly bilobed (Fig. 57b)



Figures 53a-b: Facial features in *Sympetrum*. **a**: *S. fonscolombii*; **b**: *S. striolatum*.

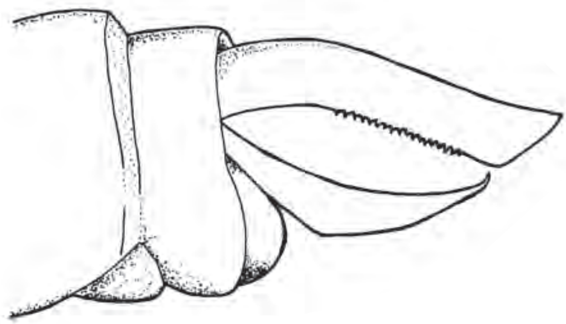
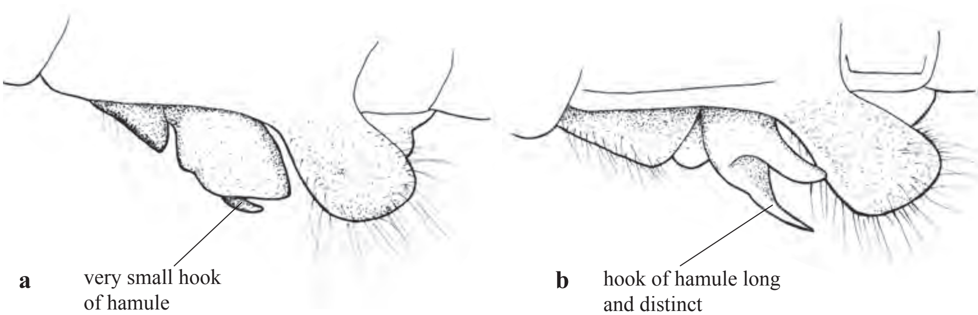


Figure 54: *Sympetrum striolatum* male anal appendages lateral view.



Figures 55a-b: *Sympetrum* male secondary genitalia lateral view. **a**: *S. fonscolombii;* **b**: *S. striolatum.*

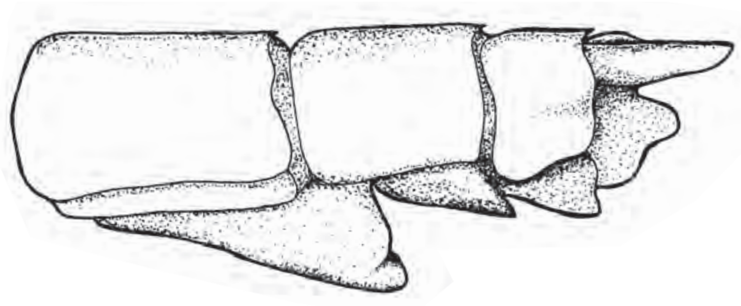


Figure 56: *Sympetrum striolatum* female abdominal hindmost segments showing extended vulvar scale.

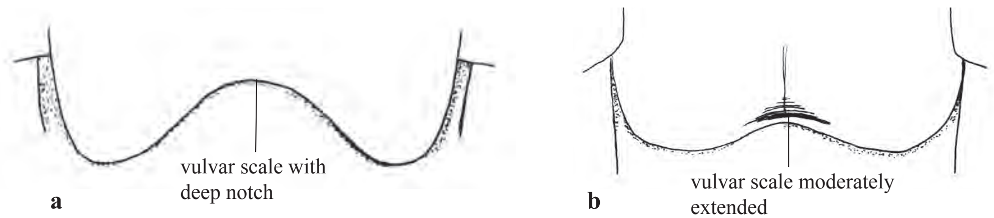


Figure 57a-b: *Sympetrum* female vulvar scales frontal view. **a**: *S. fonscolombii*; **b**: *S. striolatum* (after Dijkstra & Lewington, 2006).

Sympetrum fonscolombii (Sélys, 1840)

(Figs. 58a-f)

Red-veined Darter
Ħamrani

Status: Common and widespread.

Bl: 33 - 40 mm.
Hw: 26 - 31 mm.

IDENTIFICATION: General. The bright red fast flying males (Fig. 58a, c, e) can sometimes be confused with males of *Crocothemis erythaea*, though the latter species is somewhat larger, with a wider abdomen and with no black markings on the legs.

In the field. Mature males have a bright red abdomen. Females (Fig. 58b, c, e) are yellow with black thoracic bandings. Females can develop some red on the body. The species is difficult to separate from *S. striolatum*, but has the following distinctive features: (i) eyes in both sexes red on upper side and grey to blue on the underside; (ii) face of mature males is reddish (Fig. 53a); (iii) the frons, with a black band which extends to the sides (unlike *S. striolatum*) (Fig. 53a); (iv) whitish marking in middle of thorax in adult males; (v) red thicker wing veins at the wing base in adult males (yellow in females and young males); (vi) extensive saffron basal patches in wings, in both sexes (though locally they tend to be smaller and more intense than specimens from Italy); (vii) the pterostigma is a pale yellow with black borders; and (viii) abdomen more cylindrical than *S. striolatum*. Legs are black with a yellow stripe.

On close inspection. Male secondary genitalia (Fig. 55a) have a very small hook of hamule. Female vulvar scale (Fig. 57a) has a deep notch, rounded at tip, and exceeding S8.

Behaviour. The species is a strong migrant. Flight and behaviour are similar to that in *Crocothemis* with males being rather territorial. Males perch on prominent surfaces in their territory and periodically patrol the area. Ovipisotion occurs usually in tandem but also by the unaccompanied female. Female specimens captured by the author tended to oviposit even when hand held and their abdomen inserted in a cup filled with water (Degabriele, 1992). They have also been observed by the author to roost in the evenings in strategic areas away from water.

OCCURRENCE: Habitat. The species breeds in large but shallow still water bodies (e.g. fountains, ponds, etc). Exuviae have been found next to brackish water by the author.

Local distribution. Common and widespread across the Maltese Islands. Corso *et al*. (2012) argue that this species is in decline and is being substituted by *O. trinacria*. This claim may not have given adequate importance the fact that as records show (e.g. Ebejer *et al.*, 2008; Balzan, 2012; pers. obs, by the author) *S. fonscolombii* is locally on the wing for longer periods than *O. trinacria*, which is more likely to be encountered locally during the Summer months. This could imply that *O. trinacria* may be taking over the habitats frequented in Spring by *S. fonscolombii*. Moreover, recent fieldwork observations by the author has shown that: (i) population counts for *S. fonscolombii* were rather consistent with those carried out by the author in 1992; (ii) wherever *O. trinacria* and *S. fonscolombii* occurred together, usually over large bodies of standing water, *S. fonscolombii* generally outnumbered those of *O. trinacria*; (iii) *S. fonscolombii* occurred in a wider variety of habitats than *O. trinacria*[40] including smaller water bodies with shallower waters and with a differing amount of surrounding vegetation and (iv) *Sympetrum* can be altogether absent for a whole season (as was the case in Spring 2013), to occur again in the next, perhaps with local populations boosted by a number of migrant specimens, or perhaps due to emerging of specimens. Such findings can give the impression that the species may be uncommon and a similar occurrence could have accounted for the observed decline mentioned by Corso et *al.* (2012).

Global distribution. *Sympetrum fonscolombii* is found throughout the Mediterranean Region. It occasionally reaches northern Europe. Also found throughout Africa and the associated Atlantic islands, Middle East and most of Asia. It is the only libellulid species to be recorded in the Azores (Dijkstra & Lewington, 2006). It has expanded its range northwards in Europe (Lempert, 1997; Boudot *et al*., 2009).

Flight season. Locally recorded between March and November.

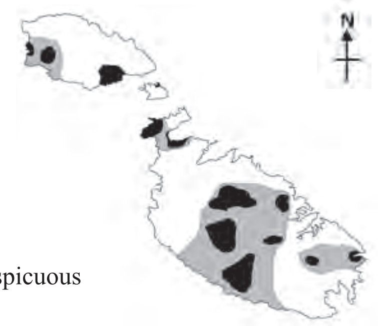
Larval stages. Larvae (Fig. 58d) have a compact body shape, with hairy processes on legs (typical of libellulid larvae). They have large bulging eyes relative to the size of the head, and no dorsal and very rudimentary lateral abdominal spines on S8-9. Setae on labial mask described in table 22. They have two prominent dark dorso- lateral stripes on abdomen. Row of setae on distal margin of S7-8 is absent (Figs. 84a, 85a) (Gerken & Sternberg, 1999; Doucet, 2010). Final instar is 14 - 17 mm long (Cham, 2007).

[40] The work by Balzan (2012) also states that the occurrence of *O. trinacria* correlates with a low habitat diversity.

Larvae survey the pond bed to capture prey such as bloodworms and mosquito larvae. Also tends to be cannibalistic. Locally they take around six months to develop into an adult (Degabriele, 1992).

Figures 58a-f: *Sympetrum fonscolombii*. **a**: male, **b**: old female; **c**: tandem pair; **d**: larva; **e**: mating pair; **f**: freshly emerged individual.

***Sympetrum striolatum* (Charpentier, 1840)**
(Figs. 59a-c)



Common Darter
Ħamrani Mitfi

Status: Scarce and localised.

Bl: 36 - 44 mm.
Hw: 24 - 30 mm.

IDENTIFICATION: General. A weaker flying and less conspicuous species than *S. fonscolombii*.

In the field. Males (Fig. 59a) have less red pigment on the weakly clubbed abdomen than *S. fonscolombii*. Females (Fig. 59b) and young males are yellowish to olive green, though older females (Fig. 59c) can develop some red. Distinguished from *S. fonscolombii* by the following features: (i) the eyes, which are red on top, yellowish on underside; (ii) the face, which is yellowish in males (Fig. 53b); (iii) the black band on the frons, which does not extend to the sides; (iv) the thorax, which in both sexes has two yellow lateral stripes which typically distinguish this species from others; the wings, which have very little or no colouring at wing base and are mostly clear, though may become brownish in older individuals and (v) the pterostigma, which is brownish. Legs are striped yellow and black.

On close inspection. The hook of the hamule (Fig. 55b) is distinct and longer than that of *S. fonscolombii*. Male anal appendages as in figure 54. Females have a moderately extended vulvar scale (Figs. 56, 57b).

Behaviour. Like *S. fonscolombii* also shows migratory tendencies. Its flight is rather slower than that of *S. fonscolombii* and typical of other *Sympetrum* species. Females have been recorded to accumulate eggs coming out from the vulvar scale in a drop of water, which adheres to the tip of the scale after every dip, and dislodge them only when females touch the water again (Corbet, 2004). They can oviposit in both fresh and slightly brackish waters. Females lay eggs both in tandem as well as unaccompanied by males.

OCCURENCE: Habitat. Can be found patrolling shallow ponds.

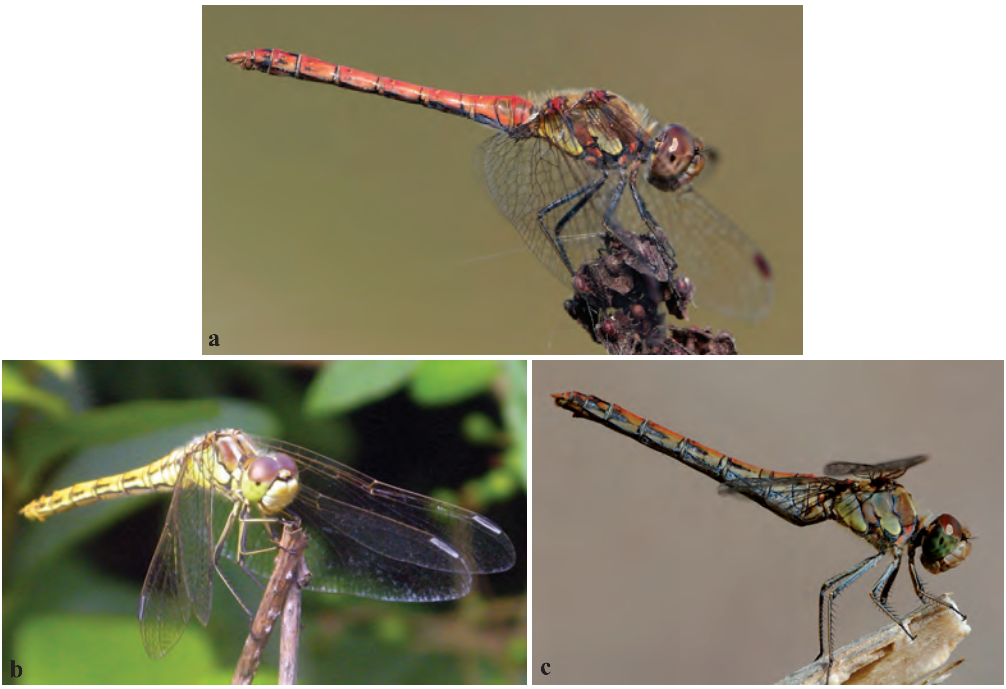
Local distribution. Described as "common but localised" (Valletta, 1949) and "very common" (Cilia, 1972) in the Maltese Islands, but found less frequently and in small numbers in studies from 1990's onwards (Degabriele, 1992; Balzan, 2012) indicating a decline in population. Corso *et al*. (2012) argue that its habitats are taken over by *O. trinacria.* However, *S. striolatum*, like *S. fonscolombii* was also found in a wider variety of habitats than *O.trinacria* by the author in Autumn 2012[41]. This could imply that *S. striolatum* can still survive in habitats where *O.trinacria* is never present. More research is needed to explain the decrease in population of this species.

[41] Wiligalla & Fartmann (2012) describe *S. striolatum* as being a habitat generalist as, in their work, the species was found to frequent different habitat types.

Global distribution. *Sympetrum striolatum* is one of the most common darters in Europe, found almost everywhere on the continent, except Iceland. Its distribution range also extends to North Africa (although records are more scattered, Boudot *et al.*, 2009), and Asia to Japan.

Flight season. Locally recorded between May - October. It has been recorded in the Mediterranean Region all year round (Dijkstra & Lewington, 2006).

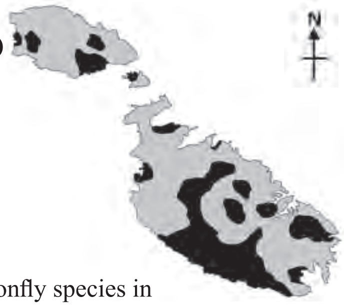
Larval stages. Larvae similar to *S. fonscolombii* in morphology and behaviour, but slightly more elongated. Setae on labial mask described in table 20. Abdomen with dorsal spines on S5 - 8 and with lateral spines on S8 - 9, the latter long (Cham, 2007) (Figs. 84b, 85b). Row of setae on posterior margin of S7 - 8 present (Doucet, 2010). They are more readily found in brackish water than other species, though no local records confirm this. Final instar is 13 - 16 mm long (Cham, 2007).



Figures 59a-c: *Sympetrum. striolatum.* **a**: male; **b**: mature female; **c**: old female.

Crocothemis erythraea **(Brulle, 1832)**
(Figs. 60-62)

Broad Scarlet (Scarlet Darter)
Skarlat



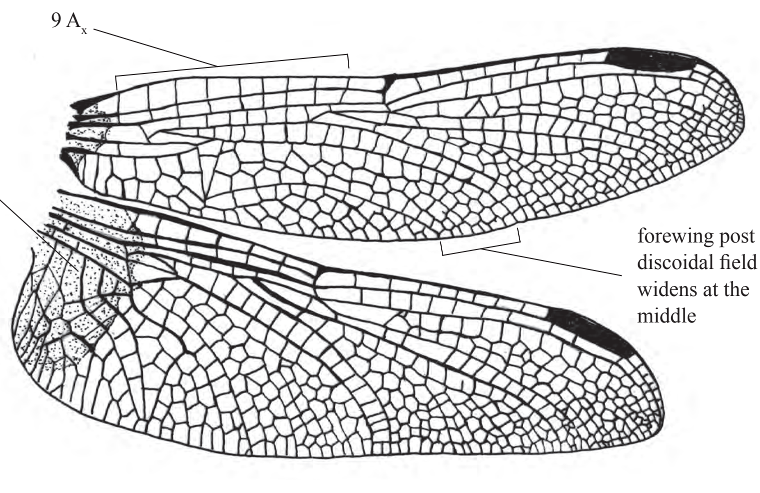
Status: Very common and widespread.

Bl: 36 - 45mm.
Hw: 23 - 33 mm.

IDENTIFICATION: General. Possibly the most common dragonfly species in the islands. The conspicuously brilliant fast flying all-red adult males (Fig. 62a) are difficult to miss.

In the field. Young males and females (Fig. 62b, d) are brownish yellow to olive in colour. Eyes in mature males are highly coloured (bright red on top, blue on bottom). Some old females can develop the male red coloration, though not as bright as males (Fig. 62c). The thorax has pale antehumeral stripes and a white dorsal area between wing bases. Wing venations can be yellow to red according to sex. Wings are clear in both sexes with a large amber patch at hindwing that fuses with wing base. The pterostigma is long and yellowish. Abdomen is distinctly wide and dorso-ventrally flattened. Legs are reddish with no black markings. The absence of black markings over the body and, particularly the legs, distinguishes this species from *S. fonscolombii* and *T. annulata*.

On close inspection. Forewing with 9 + A_x, and three cells at base of trigonal space adjacent to discoidal cell (Fig 60). Discoidal cell of forewing with crossvein. The discoidal field of forewing widens in the middle and with three rows of cells. There is one row of cells between IR_3 and rspl. Pterostigma is approximately 3.5 mm long and the pterostigmal membrane is uniformly coloured. One row of veins exist before rspl. When seen from below, the hook of the hamule in males ends in two black teeth-like structures (Fig. 61a). The vulvar scale in females distinctly juts out of the abdomen (Fig. 61b).



Figures 60: *Crocothemis erythraea* - wings.

Behaviour. Males establish territories (Fig. 62e) which are smaller than in aeshnids. Establishment of territories varies according to the orientation of the sun (Degabriele, 1993; Corbet, 2004). Males have also been known to defend territories from conspecific intruders (Corbet, 2004). Copulation (Fig. 62f) lasts only a few seconds. Females repeatedly copulate before ovipositing, accumulating sperm from successive mates (Askew, 2004). They oviposit alone, unaccompanied by males, by periodically dipping their abdomen in the water and depositing eggs whenever they make contact with water.

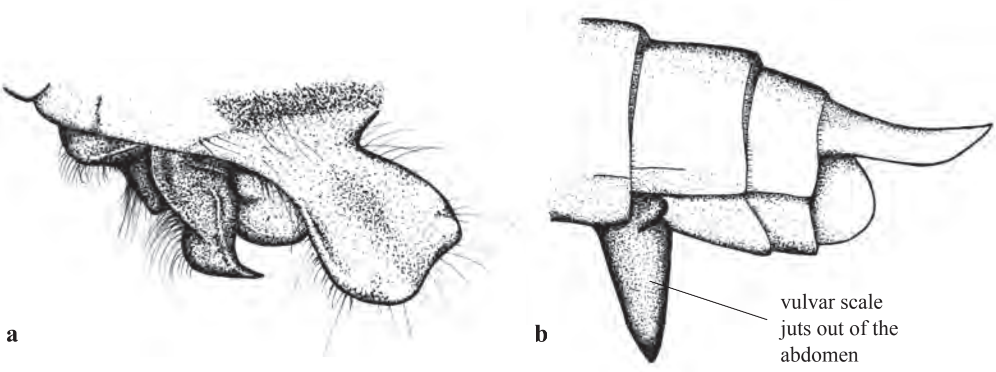
OCCURENCE: Habitat. The species frequents near-shallow stagnant water and can also tolerate some salinity. Can also be commonly found near man-made freshwater reservoirs. Exuviae (Fig. 62g) have been collected from brackish water by the author.

Local distribution. The species can be observed practically anywhere across the Maltese Islands, sometimes even in urban environments. It is also usually attracted to large blue and green objects such as cars.

Global distribution. *Crocothemis erythraea* occurs throughout most of Mediterranean Europe, North Africa, Middle East, and Asia to Pakistan. Recent records are showing that the species is spreading northwards (Dijkstra & Lewington, 2006; Boudot *et al.*, 2009).

Flight season. Local records span from March - November. Two generations are produced annually. Similar occurrence in Mediterranean Region.

Larval stages. Larvae (20 mm, Carchini 1983) (Fig. 62h) are similar in shape to *Sympetrum* larvae, but with smaller eyes, a stouter rounder abdomen and, unlike *S. fonscolombii* with no lateral and dorsal spines, and a row of well developed hair like structures, or setae on the posterior edge of S7 - 8 when seen dorsally (Gerken & Sternberg, 1999, Doucet, 2010) (Fig. 85c). Setae on labial mask described in table 20. Often found in the same habitat as *Sympetrum* larvae, and are usually sprawlers.



Figures 61a-b: *Crocothemis erythraea.* **a**: male secondary genitalia **b**: female hindmost segments showing vulvar scale.

Figures 62a-h: *Crocothemis erythraea.* **a**: male **b**: adult female; **c**: andromorphic red female; **d**: old female; **e**: male guarding territory against *Trithemis annulata*; **f**: mating pair; **g**: exuvia **h**: larva (probably F1).

Trithemis annulata (Palisot de Beauvois, 1807)

(Figs. 63a-b, 64a-f)

Violet Dropwing (Violet-marked Darter)
Vjolett

Status: Rather common, and widespread.

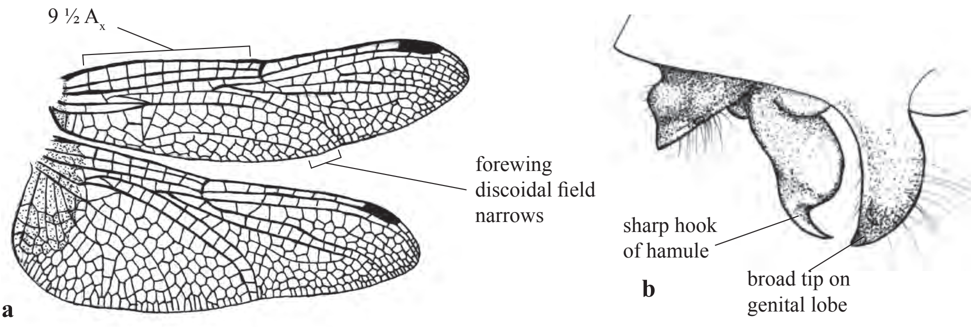
Bl: 32 - 38 mm.
Hw: 20 - 35 mm.

IDENTIFICATION: General. This is a very distinctive species, especially the purple looking, fast flying males (Fig. 64a).

In the field. Males are red and covered by suffused blue pruinosity that is obtained when fully mature, giving it a distinctive purplish appearance. Vertex and frons are metallic purple in males (Fig. 64b). In both sexes, the abdomen is fairly wide, slightly dorso-ventrally flattened and with a narrow mid- dorsal mark which terminates in a more prominent dorsal bar on S8-9. Females (Fig. 64c,d) and young males are yellowish olive in colour but may turn an orange brown when old. Both sexes have clear forewings, and hind wings that have large basal amber patches that reach to the discoidal cell. Wings have distinctive reddish venation in males and yellowish venation in females. The reddish-brown pterostigma is about 2.5-2.8 mm long, and enclosed by black veins. Legs are mainly black.

On close inspection. Wings (Fig. 63a) are distinguished from other species by: (i) the larger number of forewing antenodal veins (9 ½ = 11 ½); (ii) the row of cells between veins IR_3 and rspl is rarely double. The discoidal field of forewing narrows towards the wing border with one row of cells before rspl. The hamule of male secondary genitalia (Fig. 63b) ending with sharp hook and genital lobe ending in broad tip. Male superior anal appendage is more than twice as long as S10. Female vulvar scale is not projected ventrally.

Behaviour. Flight patterns are similar to *C. erythraea*, but the species tends to be faster and more active. Males are extremely territorial and aggressive, perching prominently on waterside jutting surfaces. They have been observed to chase away even larger species e.g. *C. erythraea* out of their territory. Oviposition has been observed by the author to occur in tandem, however females can also oviposit unaccompanied by males (Koch, 2006).



Figures 63a-b: *Trithemis annulata*. **a**: wings; **b**: male secondary genitalia lateral view.

OCCURENCE: Habitat. The species is associated with stagnant water, favouring warm spots, but may frequent slow flowing water stretches (Askew, 2004; Dijkstra & Lewington, 2006).

Local distribution. First recorded on the Maltese Islands in 2004 (Ebejer *et al.*, 2008) becoming gradually more frequent and widespread. Specimens can be observed in relatively large numbers in different localities in both Malta and Gozo.

Global distribution. *Trithemis annulata* is a very common species throughout Africa, the Middle East, Arabia and Western Asia. In Europe, more records are found in the Mediterranean, where it has extended its range to southern Spain, southern Italy, the southern Balkans, Turkey and all large islands in the Mediterranean (Boudot *et al.*, 2009). Recent records are showing that the species is also colonising other European countries, such as southern France (Dijkstra & Lewington, 2006).

Figures 64a-f: *Trithemis annulata.* **a**: male; **b**: male head; **c**: adult female; **d**: old female; **e**: eggs; **f**: exuvia.

Flight season. Locally recorded between May-October. Similar occurrence in Mediterranean basin.

Larval stages. Eggs (Fig. 64e) are somewhat dark, and slightly elliptical. Larvae (15 - 20 mm, Carchini, 1983) have a distinctive prementum with 18 setae on each side, while the labial palp with seven setae. They have prominent lateral and dorsal abdominal spines on S8 + 9 (Figs. 84d, 85d). The species is breeding localy; exuviae (Fig. 64f) have been collected from different sites.

Selysiothemis nigra **(Van der Linden, 1825)**

(Fig. 65a-b, 66a-c)

Black Pennant
Mazzarell Żgħir

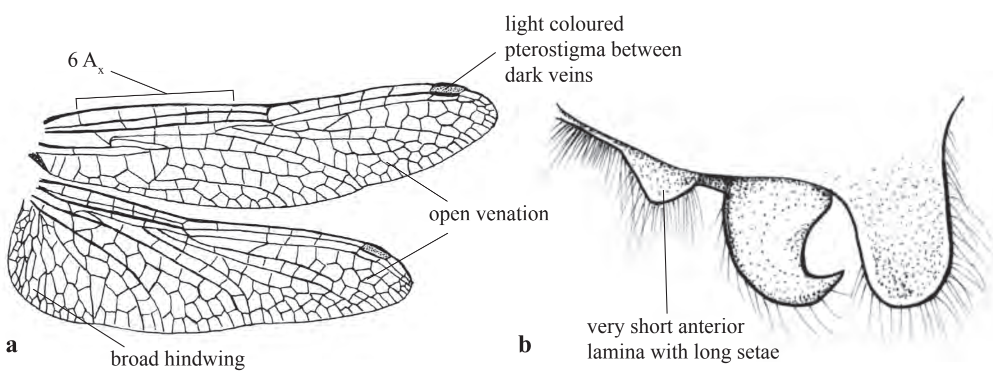
Status: Rather common and widespread.

Bl: 30 - 38 mm.
Hw: 19 - 29 mm.

IDENTIFICATION: General. A small delicate species with a large head. Adult males (Fig. 66a, c) are blackish while females (Fig. 66b-c) pale brownish yellow with brown and black body markings. Wings are clear and shiny.

In the field. The body colouring is very variable according to age and sex of the individual. Females and young males have distinctive brownish black markings on thorax, and a distinctive black lengthwise stripe on the abdomen. Males become more blackish with age and are often slightly pruinose. The particular wing venation is very open and pale, almost invisible. Hindwing is particularly broad. The distinctive pterostigma is the short, pale yellow, and heavily bordered by thick black veins. Legs are mostly black.

On close inspection. The discoidal field of the forewing (Fig. 65a) has two rows of cells (two cells adjacent to the dicoidal cell); The forewing with 6-8 A_x and one row of veins above rspl. Fw subtriangle has one cell. Two cells are found adjacent to the discoidal cell distally. Male secondary genitalia (Fig. 65b) have a very short anterior lamina covered in long setae. Female vulvar scale does not project ventrally.



Figures 65a-b: *Selysiothemis nigra.* **a**: wings; **b**: male secondary genitalia lateral view.

Behaviour. A migratory species which is often found away from water. It typically remains in a hovering position for a rather long time and perches infrequently on prominent stems or twigs with abdomen and wings slightly raised. Adults oviposit in tandem (Fig. 66c).

OCCURRENCE: Habitat. In standing shallow moderately sized water bodies. Can survive in desert regions. It is also known to survive in brackish waters in the Mediterranean (D'AGUILAR *et al.*, 1986).

Local distribution. VALLETTA (1949) recorded this species in Malta for the first time. No records of this species were made until new records in 2007 from the North and northwestern parts of Malta and Gozo (EBEJER *et al.*, 2007). Further records exist but are described as sporadic (BALZAN, 2012). It is highly likely that this species is breeding on the islands though no records of this exist to date. Fieldwork carried out by the author in Spring 2013 has recorded a number of male, female, tandem and ovipositing specimens of *S. nigra* at Imselliet, Qlejgħa and Ħesri valleys, implying that the distribution of this species on the islands is increasing.

Global distribution. The species is found in southern Europe and North Africa, to mid-western Asia as far as Turkestan (ASKEW, 2004; BOUDOT *et al.*, 2009).

Flight season. Local records from May - September. Similar records in Mediterranean Region.

Larval stages. Larvae superficially similar to *Trithemis annulata*, with which it shares the same habitat. They grow smaller than in some other libellulids (20 mm, CARCHINI, 1983). The most distinctive feature is the moderately dorso ventrally flattened head (Fig. 82c) and the narrower and longer eyes (CARCHINI, 1983). Life cycle is probably short (BOUDOT *et al.*, 2009).

Figures 66a-c: *Selyothemis nigra.* **a**: male; **b**: female; **c**: tandem pair.

Pantala flavescens **(Fabricius, 1798)**
(Figs, 67a-b, 68a-d)

Wandering Glider (Globe Skimmer)
Kożmopolitan

Status: Single record. New to the Maltese Islands.

Bl: 45 - 55 mm.
Hw: 38 - 42 mm.

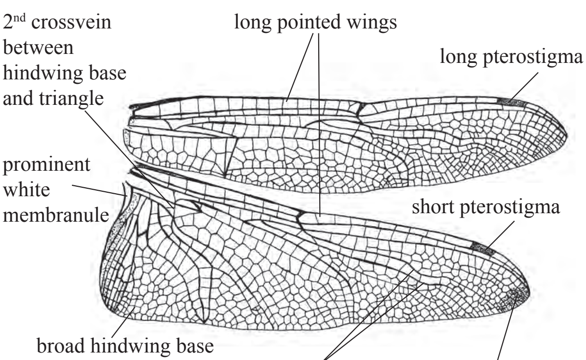
IDENTIFICATION: General. A large species with a strong patrolling flight. Wings are long and pointed and hindwings have a broad base.

In the field. Males (Fig. 68a) are of a yellowish hue suffused with red or orange. Females tend to be more yellowish. Male wing tips are brown, particularly in the hindwing. The abdomen is rather cylindrical and tapered and has black dorsal markings which are different from those found in other locally occurring libellulid genera.

On close inspection. R_3 and IR_3 veins are rather wavy (Fig. 67a). Wings have a prominent white membranule. The pterostigma is a reddish-brown and rather short, with the hind wing pterostigma clearly shorter than that on the forewing. The anal area of the hindwing is suffused with amber, particularly in females. S5 possesses a transverse ridge, a feature which is not found in any other species occurring in the Palaearctic Region. Appendages in both sexes are rather long.

Behaviour. This species is a strong flier which perches seldom. It is one of the world's most famous migrant species and is often seen in migratory swarms in places where common. It is capable of colonizing temporary water habitats and completing its life cycle in a very short span (Dijkstra & Lewington, 2006).

OCCURENCE: Habitat. The species inhabits small water bodies of stagnant to semi-stagnant temporary water bodies. Two local records were found patrolling pools which were shaded by trees (Figs. 68c-d).



a

b

Figures 67: *Pantala flavescens.* **a**: wings **b**: male secondary genitalia.

Figures 68a-d: *Pantala flavescens.* **a**: male; **b**: the male specimen captured at Fiddien valley; **c**: the pool at Qlejgħa valley where the first sighting occurred; **d**: the pool at Fiddien valley where the specimen in figure 68b was captured.

Local distribution. Two specimens have been observed by the author in Summer 2013, the first being from Qlejgħa valley in August 2013 patrolling a small sheltered pool that formed following a stormy August day. The second record consists of a male specimen which was captured from Fiddien valley on 25.ix.2013 (Fig. 68b). A third record by the author was spotted at Ħesri valley, on 31.x.2013.

Global distribution. *Pantala flavescens* is a very common species throughout the tropics and North America, however, records of the species from the Palaearctic Region are rather scarce. It is rather common in the European part of Turkey, and Cyprus. A scattering of records of this species also exist from other countries in Europe and the Mediterranean Region specifically from northeastern Greece, Rhodes, Montenegro, Morocco, Tunisia, south Algeria and Egypt (Boudoit *et al*., 2009). The records from England in the early 19th century (e.g. 1823 in England, Sélys & Hagen, 1850; Lucas, 1900 all in Askew, 2004), France and Spain from the 1960's are nowadays considered dubious (Dijkstra & Lewington, 2006). More records of this species are to be expected in the Mediterranean in the future (Dijkstra & Lewington, (2006). The most recent records come from the Italian Pelagic Islands (Corso *et. al*, 2012).

Flight season. This species has been observed on the wing from June to September in Turkey. Local records were taken in August, September and October.

Larval stages. Larvae have a very short life cycle, lasting only about one month (Dijkstra & Lewington 2006). Askew (2004) describes the larva as having the following features: (i) occiput no more than twice as long as relatively longer eyes, with lateral margins strongly convergent; (ii) body less hairy; (iii) legs long and slender; (iv) abdomen without mid dorsal spines; (v) S8+9 with well developed lateral spines (those on S9 as long as the segment); (vi) labial palp with fourteen to sixteen setae and (vii) body length at least 25 mm.

VAGRANT RECORDS

Family Calopterygidae

This family includes large damselflies with broad and oval-shaped, wings. Females usually have a metallic green body and clear to brown wings, while males have a metallic blue body and irridescent wings. The wings are densely veined and do not narrow to a petiole at the base. The pterostigma is small and absent in males, while females have pale pseudopterostigmas which are weakly defined and have crossveins. These insects fly by slowly flapping their wings, a behaviour which is reminiscent of Lepidoptera (butterflies), settling frequently on the waterside vegetation. They keep their wings closed and their abdomen raised when at rest. Males are territorial, and attract females by displaying their 'tail lights' (underside of abdomen tip) in elaborate courtship flights. Two species have been recorded in the Maltese Islands.

Calopteryx virgo (Linnaeus, 1758)
(Fig. 69)

Beautiful Demoiselle

The largest *Calopteryx* of its kind in Europe, with conspicuously metallic blue males (Fig. 69) and metallic green females. Wings are broad and hindwings have a paddle like appearance. Male wings appear a purplish blue and may or may not have the basal area or wing tip or both clear depending on the subspecies and distribution range. Female wings are pale brownish. The male 'tail light' is brown to reddish with extensive black markings (Dijkstra & Lewington, 2006). They usually frequent shady areas close to running waters sometimes in higher latitudes (Dijkstra & Lewington, 2006). A few records exist, all discovered from old collected material, some of which belonging to the late A. Valletta, dating from the early 1970's to the mid 1990's, from the South-East of Malta, and from Gozo[42]. The specimens are believed to belong to the ssp. *meridionalis* since the wing coloration extends to the wing tip (Corso *et al.*, 2012). No other records exist. These records are highly likely to have been of vagrant specimens or even accidental introductions, since the preferred habitats of the species are rarely found, if at all, on the Maltese Islands and the distribution range of the species does not include areas close to the Maltese Islands. *Calopteryx virgo* is widely spread and locally common across the Mediterranean Region, but scarcer towards the South. Very few pre1980 records and no modern records from Sardegna and Sicily, and even fewer from Northern Africa (Algeria, Morocco) where it is considered to be critically endangered (Boudot *et al.*, 2009).

[42] The existence of such specimens, together with a specimen of *Aeshna mixta* in Valletta's collection is first mentioned in the unpublished work by the author (Degabriele, 1992) though these specimens are mistakenly referred to as "*being Aeshnids*" (pg.9), since no access to such specimens was possible at the time.

Figure 69: C*alopteryx virgo meridionalis* male.

***Calopteryx haemorrhoidalis* (Van der Linden, 1825)**
(Fig. 70)

Copper Demoiselle

Males (Fig. 70a) are variable in colour, from typically reddish bronze with brown to purplish, dark, blue, olive or almost black. Females (Fig. 70b) can be of a metallic green to a bronze coloration. Male wings are coloured brown (rather than bluish-purple as in *C. virgo*) also with clear wing bases, wing tips or both depending on subspecies. Female wings are clear and pale brownish with dark tip on hindwing and a contrasting white pseudopterostigma. The tail light of the males is distinctively bright pink to vivid red. The species can be found around clear rivers and streams but also in larger waters in full sun (Dijkstra & Lewington, 2006).

Specimen records come from the same material researched for C. *virgo* dating from the 1980's. Because of the bad state of preservation, one of the specimens had been formerly identified as *C. virgo* (Corso *et al.*, 2012). No other records exist. Because of its habitat preferences and distribution range, this species is a more likely visitor to the Maltese Islands. *C. haemorrhoidalis* occurs in the western Mediterranean region including the major islands. It is rather common and widespread in Northern Africa (Boudot *et al.*, 2009).

Figure 70: *C. haemorrhoidalis.* **a**: male; **b**: female.

Other possible vagrants

Tables 10 and 11 contain lists of odonate species that may be likely to occur on the Maltese Islands. These lists have been compiled in consultation with Dr. K.D. Dijkstra.

Figures 71a-f: Some expected vagrant zygopteran species in the Maltese Islands. **a**: *Lestes barbarus* male (Italy); **b**: *Lestes macrostigma* male (Italy); **c**: *Sympecma fusca* male (Germany); **d**: *Coenagrion scitulum* male (Italy); **e**: *Coenagrion caerulescens* male (France); **f**: *Ischnura fountaineae* mating pair (Tunisia).

Table 10. Possible vargant species of Zygoptera in the Maltese Islands.

Taxon	English Name	Occurrence	Reason
Lestes barbarus (Fabricius, 1798) (Fig. 71a)	Migrant Spreadwing	expected	possible vagrant
Lestes macrostigma (Eversmann, 1836) (Fig. 71b)	Dark Spreadwing	possible	slight chance of population in saltmarshes (*Bolboschoenus maritimus*). Found on Sardinia; extinct Sicily
Lestes virens (Charpentier, 1825)	Small Spreadwing	unlikely	unlikely vagrant
Lestes viridis (Vander Linden, 1825)	Western Willow Spreadwing	unlikely	unlikely vagrant
Sympecma fusca (Vander Linden, 1820) (Fig. 71c)	Common Winterdamsel	expected	possible vagrant
Coenagrion caerulescens (Fonscolombe, 1838) (Fig. 71d)	Mediterranean Bluet	expected	possible vagrant
Coenagrion mercuriale (Charpentier, 1840)	Mercury Bluet	unlikely	unlikely vagrant
Coenagrion ornatum (Sèlys, 1850)	Ornate Bluet	unlikely	unlikely vagrant
Coenagrion puella (Linnaeus, 1758)	Azure Bluet	unlikely	unlikely vagrant
Coenagrion scitulum (Rambur, 1842) (Fig. 71e)	Dainty Bluet	expected	possible vagrant
Ceriagrion tenellum (Villers, 1789)	Small Red Damsel	unlikely	unlikely vagrant
Erythromma lindenii (Sèlys, 1840)	Blue-eye	unlikely	unlikely vagrant
Ischnura fountaineae (Morton, 1905) (Fig. 71f)	Oasis Bluetail	possible	slight chance of population in saltmarshes, found on Pantellaria
Ischnura pumilio (Charpentier, 1825)	Small Bluetail	unlikely	unlikely vagrant

Table 11. Possible vagrant species of Anisoptera in the Maltese Islands.

Species	English Name	Occurrence	Reason
Aeshna isoceles (Müller, 1767) (Fig. 72a)	Green-eyed Hawker	expected	possible vagrant
Aeshna affinis (Vander Linden, 1820) (Fig.72b)	Blue-eyed Hawker	expected	possible vagrant
Paragomphus genei (Selys, 1841) (Fig. 72c)	Green Hooktail	expected	quite a mobile African species, known also from Sicily and Sardinia
Paragomphus leucosticta (Burmeister, 1839)	Banded Groundling	possible	known from Tunisia, Sicily and Sardinia
Diplacodes levebvrii (Rambur, 1842) (Fig. 72d)	Black Percher	expected	southern species known from Tunisia, likely to expand North
Libellula depressa (Linnaeus, 1758)	Broad-bodied Chaser	unlikely	unlikely vagrant
Sympetrum meridionale (Selys, 1841) (Fig. 72e)	Southern Darter	expected	possible vagrant
Sympetrum sinaiticum Dumont, (1977) (Fig. 28f)	Desert Darter	possible	recorded from the Sicilian Channel (Corso *et al*., 2012)
Trithemis arteriosa (Burmeister, 1839) (Fig. 72g)	Red-veined Dropwing	expected	southern species known from Tunisia, likely to expand North
Trithemis kirbyi (Sèlys, 1891) (Fig. 72h)	Orange-winged Dropwing	expected	southern species known from Tunisia, likely to expand North (discovered in Spain in 2007)
Zygonyx torridus (Kirby, 1889)	Ringed Cascader	possible	possible vagrant, but very few records only from Tunisia and Sicily (though may be expanding)

Figures 72a-h: Some expected anisopteran species in the Maltese Islands. **a**: *Aeshna isoceles* male (Italy); **b**: *Aeshna affinis* male (Germany); **c**: *Paragomphus genei* male (Italy); **d**: *Diplacodes levebvrii* male (Tunisia); **e**: *Sympetrum meridionale* male (Germany); **f**: *Sympetrum sinaiticum* male (Tunisia); **g**: *Trithemis arteriosa* male (Tunisia); **h**: *Trithemis kirbyi* male (Tunisia).

ODONATE DENTIFICATION FOR ADULTS AND LARVAE

Identification key to adults

The following key (table 12) summerizes the features of the suborders, families, genera and species of odonates of the Maltese Islands. It aims to facilitate adult species identification.

Table 12. Key to identify the Odonata of the Maltese Islands

	Feature	↓
1	Generally smaller and of slender build, weak flyers with slow wingbeat, eyes widely separated and do not cover top part of head, wings with simple venation, similarly shaped and petiolate, hindwing narrowed in basal half (widest part beyond midpoint), wings usually held together over abdomen, discoidal cell four-sided referred to as the quadrilateral, pterostigma rather short and may be absent, male anal appendages include two superiors and two inferiors, female ovipositor always present, ovipisition always endophytic.	Zygoptera (see 2)
	Larger and more robust, strong flyers with very fast wingbeat, wings never petiolate, with complex venation, and hind wing considerably wider than forewing, eyes large and globular, confluent and touch top of head; wings kept wide open; discoidal cell three-sided making up the triangle and hypertriangle, pterostigma is elongated, male anal appendages include one superior pair and a single inferior appendage, female ovipositor only present in aeshnids, others have a reduced structure known as vulvar scale, oviposition endophytic only in aeshnids - in libellulids it is exophytic.	Anisoptera (see 3)
2	Body size > 40 mm, metallic body (males typically copper in *Calopteryx haemorrhoidalis*, metallic blue in *C. virgo,* females green in both species), males with coloured "tail lights" on ventral side of abdomen, head not as follows, wings coloured (brown in *C. haemorrhoidalis*, blue in *C. virgo*) and with 18 Ax in forewing, quardrilateral is a narrow rectangular series of many cells, pterostigma absent in males, pseudopterostigmas in females, legs long, spidery and with long bristles.	Calopterigydae *Calopteryx*
	Body size < 40 mm, body rarely metallic (not in *I.genei*), head about 2 x as wide as long and with pale band in front of vertex, or behind it/ or with post ocular spots (the latter in *I.genei*), wings clear and with only 2 A_x in forewing, cells in wing mostly quadrangular to quardrilateral and has the shape of a skewed trapezium, pterostigma is diamond-shaped (bi-coloured in *I. genei* males), tibiae thin and often dark, "tail lights" present in both sexes on dorsal side of abdomen.	Coenagrionidae *Ischnura genei*
3	Labium consisting of large middle lobe with median structure, with lateral lobes widely separated and middle lobe of labium entire or with only a minute apical notch, A_x with two primary antenodals prominent while remaining ax not aligned over costal and subcostal spaces, discoidal cells similarly shaped in both wings and equidistant from arculus, pterostigma with oblique crossvein brace at proximal end, body size always > 50 mm, blue spots always present coloured by internal pigments, body never pruinose, eyes contiguous dorsally acute corner of triangle points outwards, auricles can be present laterally on 2nd abdominal segment, females with complete ovipositor and oviposit endophytically, flies for long periods and perches seldom amongst vegetation hanging vertically.	Aeshnidae (see 4)
	Labium, Ax, discoidal cells, pterostigma not as above, body size 50 mm or smaller, body can have various colours though seldom metallic, and can be pruinose (except *Selysiothemis* and *Pantala*), eyes with posterior margin without prominence and no obvious indentation on external posterior edge, acute corner of triangle points backwards, auricles never present, females never have a fully developed ovipositor but a vestigial one in the form of the vulvar scale, and oviposit exophytically, performs short, but occasionally long flights, perches often and for longer periods.	Libellulidae (see 7)

	Feature	↴
4	Anal triangle present with 2-4 cells, hindwing base angled, end of rspl points towards a part of the wing posterior of the tip, R_3 forms regular curve under pterostigma, pterostigma is less angulated, abdomen is waisted, auricles on S2 present in males, thorax inlaid with coloured bands, abdomen with coloured spots, IR_3 fork present, 3-5 rows of cells above rspl and mspl, females usually ovposit alone (as is the case in *A. mixta*)	*Aeshna mixta*
	Anal triangle absent, hindwing base smoothly rounded, end of rspl points towards a part of the wing anterior of the tip, R_3 is abruptly arched forward near distal end of pterostigma, abdomen is not waisted, auricles on S2 absent in males, thorax often uniformly coloured and not banded, abdomen not banded, uniformly green, blue or brown and with broad black mid dorsal stripe, Ir fork absent, 4-5 rows of cells above rspl and mspl, females oviposit alone or in tandem	*Anax* (see 5)
5	Distinctly smaller, eyes brown above and (greenish) yellow below, underside never blue, frons with black bar on crest and never blue at base, thorax brown often inconspicuously tinted in the central part, cells between cubital and anal vein rather irregularly arranged, abdomen slender and as long as hindwing, S1 with brown basal ring, abdomen brown-yellow marked with bright blue only on S2 and base of S3 (pale markings thereafter duller and darker), saddle distinct in males (less in teneral males and females) and does not wrap round segment (sides dull yellow), ground body colour brown/ straw coloured, S8-10 blacker than above leaving only clearly defined pale spots at hind corners of segments. Male inferior appendage triangular and with a large amount of denticles on outermost tip	*A. ephippiger*
	Larger, abdomen thick and longer than hindwing. Other features not as above	(see 6)
6	Eyes green to blue above and yellow-green under, frons with with black pentagon at base, female with no occipital tubercles, thorax green, wings may be tinted between triangle and tip, S1 green or sometimes blue, basal ring green (yellow when young), male abdomen bright blue on S2-10, saddle not distinct, ground body colour green turning blue in mature individuals, S8-10 Colour markings similar to preceding segments sometimes brownish, male inferior appendage 1/3 as long as superior (apically truncated in dorsal view) male superior appendages not as below	*A. imperator*
	Eyes uniformly green sometimes tinged with yellow/ blue and/or brown, frons with lack triangle at base, female with two occipital tubercles, thorax purplish brown, wings often conspicuously tinted brownish between node and pterostigma, S1 never green, basal ring yellow, male abdomen marked with bright blue only on S2, saddle and base of S3 very prominent (pale markings thereafter duller and darker), ground colour brown-bluish, S810 as above but sometimes blacker, male inferior appendage less than 1/5 as long as superior, apically bilobed without any clearly defined sub basal tooth, Male superior appendages expanded medially only about 3 times as long as max breadth apically rounded without a clearly defined subbasal tooth	*A. parthenope*
7	Body size medium to large (45-55 mm), wing tips dark, Fw A_x 12-14 $^1/_2$ IR_3 and R_3 wavy, transverse ridge present on S5, hindwing pterostigma is shorter than forewing, long appendages in both sexes	*Pantala flavescens*
	Not as above	(see 8)

	Feature	↓
8	Males blackish, females a sandy colour with back dorsal and lateral stripes, pterostigma short and pale, Fw Ax = 6, Fw subtriangle with 1 cell, 2 cells adjacent to discoidal cell distally, abdomen regularly shaped	*Selysiothemis nigra*
	Not as above, Fw Ax >6, Fw subtriangle with 3 cells, 3 cells adjacent to discidal cell distally	(see 9)
9	Male red and sometimes pruinose giving an overall purplish look, females yellowish becoming brown, amber patch on hindwing sometimes present	Reddish/ purplish species (see 10)
	Overall colour varies but never bright red. Abdomen in females usually becomes pruinose (grey blue), amber patch on hindwing always absent	Orthetrum (see 13)
10	Adult male red and pruinose giving an overall purplish look, females yellowish becoming brown when old, pterostigma dark approx. 2.6 mm, Fw Ax = 9 ½ - 11 ½, discoidal field narrows appreciably. Fw discoidal field narrows. Legs mainly black	*Trithemis annulata*
	Not as above	(see 11)
11	Overall colour red in males and yellowish in females, upper part of frons wide,prothorax not as below, pterostigma approx 3.5 mm, pterostigmal membrane uniformly coloured, Fw A_x = 9+, Fw discoidal field widens significantly, amber patch on hindwing always present, legs reddish and no black markings	*Crocothemis erythraea*
	Overall colour brown and red, or red in males, yellowish with lateral and dorsal black stripes in females (but may also be reddish), upper part of frons narrow, prothorax with well developed raised posterior lobe, Fw A_x = 8½ - 10 ½, Fw post discoidal field does not widen significantly, amber patch on hindwing not always present, Legs black with yellow stripe	*Sympetrum* (see 12)
12	Frons yellow in both sexes, sides of thorax with conspicuous sutural stripes, wing veins not as below, pterostigma brownish and darker, hindwing with no amber patch, pterostigma dark, abdomen weakly clubbed, lateral black abdominal markings more prominent, secondary male genitalia with anterior process of hamule longer than posterior process and with small terminal hook, female vulvar scale more pressed towards abdomen, prominent and not strongly bilobed	*S. striolatum*
	Frons in adult males reddish, thorax not as above, many wing veins in basal thirds of wings, wing venation reddish in males and yellowish in females, wings with amber patch present, invades one or several cells of foot shaped anal loop, ptrerostigma pale yellow with contrasting broad black borders, abdomen not weakly clubbed, male secondary genitalia not as above, female vulvar scale deeply incised and bilobed	*S. fonscolombii*
13	Body never smaller than 43 mm, when not pruinose, body black with pale streaks or rings, row of cells between IR_3 and rspl veins partially double, pterostigma yellowish to brown, abdomen cylindrical and thin – at least as long as hindwing, S2 + 3 swollen and three times as thick as other segments, maximally at least four times as deep as S4	*Orthetrum trinacria*
	Not as above	(see 14)

	Feature	↴
14	Body larger, S10 dorsally yellow and brown, and mid dorsal abdominal carina on central abdominal segments yellow with only the spikules dark, in females and young males abdomen is patterned on abdomen with two black longitudinal stripes, S3-8 with broad black lateral lines which curve inwards above lateral carina to isolate yellow spots, male superior anal appendages black in both sexes, light costal veins, pterostigma blackish and smallish	*O. cancellatum*
	Not as above	(see 15)
15	Body length seldom exceeding 4.6-4.9 mm, vein R_1 yellowish to the level of the node, post costal part of costa very pale, 2 rows of cells in rspl, pterostigma large, membranule pale, female abdomen with S8 with the ventral edge straight (lower border straight not curved) when seen in profile, distribution southwest and declining	*O. nitidinerve*
	Not as above	(see 16)
16	Medium/ large body size - smaller than *nitidinerve*, thorax with one pale dark bordered stripe immediately behind humeral suture, ½ rows under rspl, membranule dark with small yellow patch in adjacent hindwing (infuscate), abdomen waisted, distribution south	*O. chrysostigma*
	Not as above	(see 17)
17	Body medium sized (36-45mm), face brownish and never bluish, one row of cells above rspl in most wings, pterostigma small and yellowish to brown 2.5 - 3.0 mm long not longer than the breath of the abdomen, membranule, intermediate shade, has a pair of spots which flank the mid-line with which they often fuse, male secondary genitalia with anterior lamina triangular in profile pointed and slightly longer than in other species	*O. coerulescens anceps*
	Body larger, seldom exceeding 45mm, face bluish, vein R_1 black, row of cells between veins IR_3 and rspl extensively (at least four cells) doubled, pterostigma large and dark brown at most 3.0 mm long usually less, membranule pale (whitish), abdomen rather broad without broad black lateral lines but a fine mid- dorsal carina abdomen shorter than hindwing somewhat compressed dorsoventrally and triquetral, has a pair of spots which flank the mid-line and never fuse with it S2 and S8 maximally twice as deep as S4, females in profile with ventral edge slightly convex, male secondary genitalia with anterior lamina in profile much shorter than the conspicuously bilobed hamule, widespread distribution	*O. brunneum*

Identification tables for larvae

The identification system adopted hereunder follows the style of Dijkstra & Lewington (2006) as this was found to be more descriptive than dichotomous keys, which identify species by elimination. *Aeshna mixta*, *Anax ephippiger*, *Orthetrum brunneum*, and *Selysiothemis nigra* are likely to breed on the Maltese Islands, and have therefore been also included in the tables. The Family Calopterigydae has been omitted in this section, since both records of *Calopteryx* species from Malta are unlikely to breed locally. Not enough data on whether the larvae of *Orthetrum nitidinerve*, *O. chrysostigma* and *Pantala flavescens* are breeding on the Maltese Islands is available, therefore larval characteristics of these species have been omitted from the following tables (table 13-21).

Table 13. Features of suborders Zygoptera and Anisoptera.

Body shape	Head shape	Labial mask shape	Caudal lamellae	Anal appendages	Abdominal spines	Swimming behaviour	↴
Long and slender	Much broader than abdomen	Flat and relatively narrow at labial extremity which are richly supplied with tracheal tubes to maximize the efficiency of gaseous exchange	Three flat lamellae projecting from abdomen[43]	Absent	Absent	Lateral movements of abdomen	**Zygoptera**
Robust frequently short rounded and broad (e.g. libellulids), but sometimes elongated or flattened (e.g. aeshnids)	Only slightly broader than abdomen	The labial mask is variable in length and shape, often rounded to cover the face (e.g. in libellulids). Varies per family and is diagnostic of species (see table 15)	Absent and replaced by internal gills	Five short anal appendages	Usually present. Number varies per species and is a diagnostic feature	Sudden expulsion of water from abdomen	**Anisoptera**

[43] in Calopterigydae only the middle lamella is flat.

Table 14. Features of the family Coenagrionidae, *Ischnura genei.*

Feature	Coenagrionidae
Antenna	First segment longer than pedicel
Labial mask	Setae arranged in two lateral oblique rows.
Prementum	Has at least four long setae arranged in two oblique series with the mesial ones more basal in position than outer ones
Caudal lamellae	Apically rounded or with short points (often divided transversely in two parts).
Pronotum	Smooth and with no tubercular formations
Feature	***Ischnura***
Caudal lamellae	Long and slender and pointed, about four times as long as broad, and with thicker setae reaching to and beyond mid-point on only one margin and to about $^{1}/_{3}$ of the length of the other margin
Feature	***I. genei***
Labial palp (Fig. 73)	6 - 7 setae[44] Apex between movable hook and end hook with a seven toothed margin (only 3 - 4-toothed in *I. elegans*)
Prementum (Fig. 73)	4-5 setae (as in *I elegans*). Lateral margin with 4 setae (8-9 in *I. elegans*, Conci & Nielsen, 1956)

Table 15. Features of the families Aeshnidae and Libellulidae.

Body shape	Antennae	Labial mask and palp	Prementum	Legs	Hind leg size	Cerci	↴
Elongated and "torpedo shaped" (Cham, 2007)	Long threadlike and six-seven segmented, with third segment smaller than others	Labial mask flat (Fig. 74a). Hook on labial palp longer than breadth of labium. Distal margin of labial palp with no crenations or setae	Not as below	All three pairs with three tarsal segments	Does not reach apex of abdomen	Not as below	**Aeshnidae**
Rather squat and dorso ventrally flattened	Not as above	Labial mask rounded (Fig. 74b). Hook on labial palp shorter than breadth of labium. Distal margin of labial palp with uniformly deep crenations	Apex not bifid	Short and robust with femora covered in soft long setae	Reaches beyond apex of abdomen	Less than half as long as paraprocts	**Libellulidae**

[44] also in *Ischnura elegans*.

Table 16. Features of the genera *Aeshna* (and *A. mixta*) and *Anax*.

Head	Eyes	Lateral abdominal spines	Anal Pyramid	↴
When viewed dorsally, head appears rounded. Labial mask narrow at basal third (Fig. 75a)	When seen dorsally, eyes broader than long	In *A. mixta*, spines in S9 reaching at least as far as middle of S10	Tip pointed (Fig. 77a)	***Aeshna***
When viewed dorsally, head does not appear rounded. Labial mask wider at basal third (Fig. 75b)	When seen dorsally, eyes longer than broad	Present on S7-S9	Tip blunt (Fig. 77b)	***Anax***

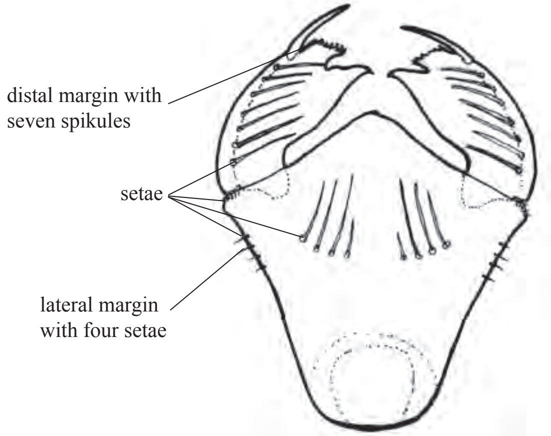
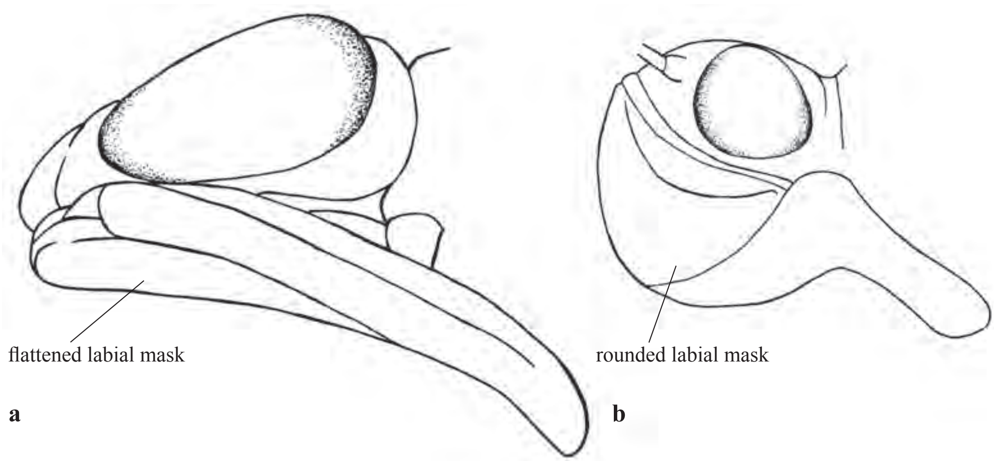
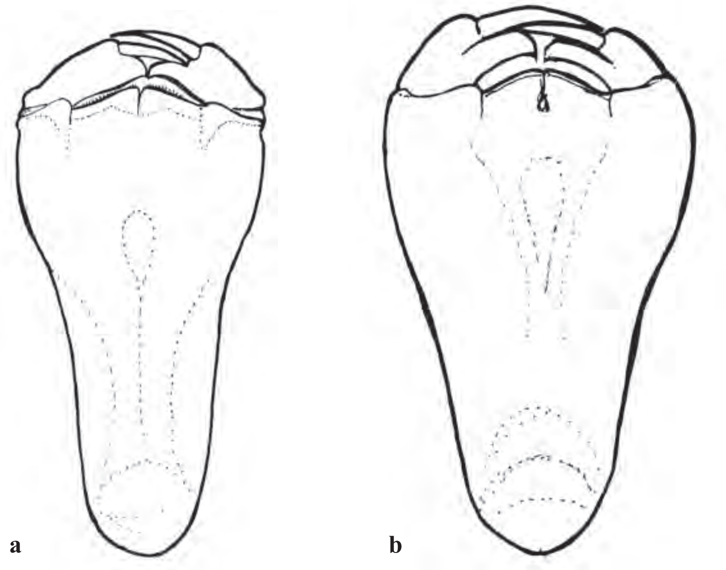


Figure 73: *Ischnura genei* labial mask.



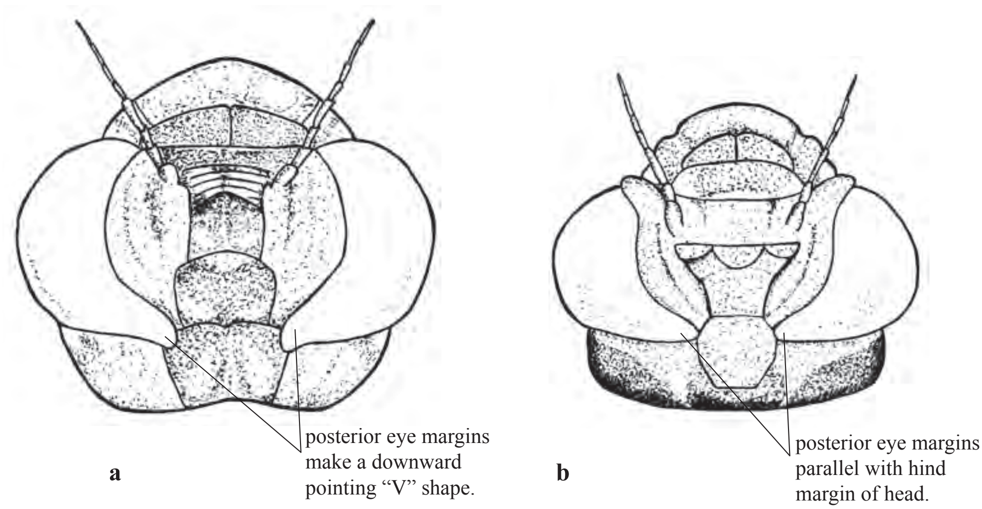
Figures 74a-b: Anisopteran labial masks. **a**: Aeshnidae (*Anax imperator*); **b**: Libellulidae (*Sympetrum striolatum*).



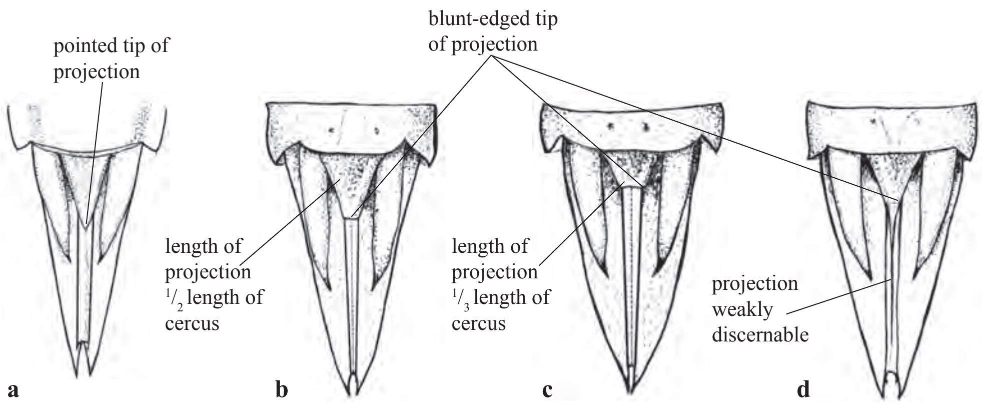
Figures 75a-b: Labial masks. **a**: *Aeshna*; **b**: *Anax*.

Table 17. Features of *Anax imperator*, *A. parthenope* and *A. ephippiger*.

Body length	Head	Male caudal pyramid	Female abdomen	Prementum	↴
45 - 56 mm	Length and breadth about equal giving approximately circular appearance. Hind margins of eyes make a slight “V” shape pointing to hind margin of head (Fig. 76a)	Male projection at base of epiproct as long as broad - half a length of cercus (Fig. 77b)	Ovipositor length relative to S9 is larger	Long, with length: breadth ratio = 1: 3.375 (Fig.75b)	***A. imperator***
As above	As above	Male projection at base of epiproct one half as long as broad = $^1/_3$ length of cercus (Fig. 77c)	Ovipositor length relative to S9 is smaller	As above	***A. parthenope***
42.5 - 44 mm	Hind margins of eyes roughly in a straight line parallel with hind margin of head (Fig. 76b)	Male projection at base of epiproct not clearly differentiated and apically acute (Fig. 77d)	Not as above	Short, with length: breadth ratio = 3:4	***A. ephippiger***



Figures 76a-b: *Anax* heads. **a**: *A. imperator*; **b**: *A. ephippiger.*

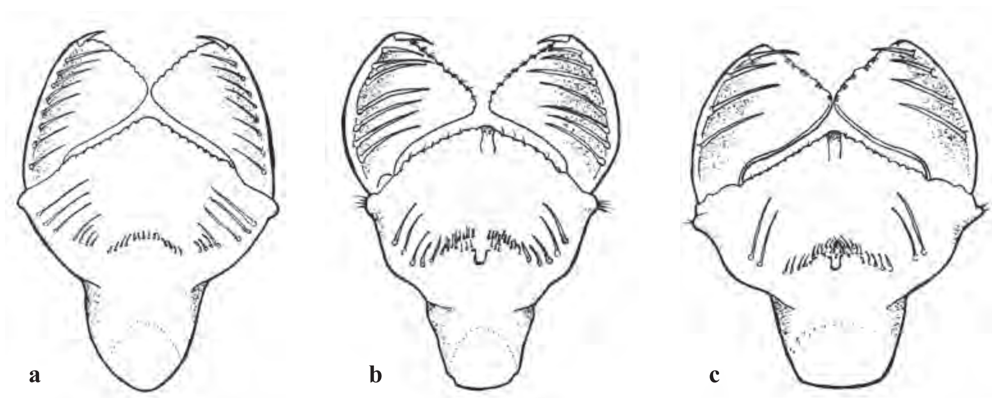


Figures 77a-d: Caudal pyramids. **a**: *Aeshna mixta*; **b**: *A. parthenope*; **c**: *A imperator*; **d**: *A. ephippiger.*

Table 18. Features of the genus *Orthetrum*.

Feature	*Orthetrum*
Body shape	Large and robust
Hairs/setae	Body very hairy, often covered with pond debris
Head (Fig. 78)	Has a rectangular shape. When viewed dorsally with occiput at least a twice as long as the small and prominent eyes and with lateral margins sub-parallel behind eyes
Eyes	Small, occupying not more than 1/4 lateral profile of head and do not touch labial mask when viewed frontally
Post-ocular lobes	Large
Thorax	Wide, particularly in the pronotal region which is only marginally less wide than head.
Legs	Shorter and stouter and covered in hairs. femora curved and hairy
Abdomen	S8 without medio-dorsal spine, but sometimes with tufts of hair simulating a spine. Posterior end tapers gradually
Larval behaviour	Not mobile, usually found encrusted in debris

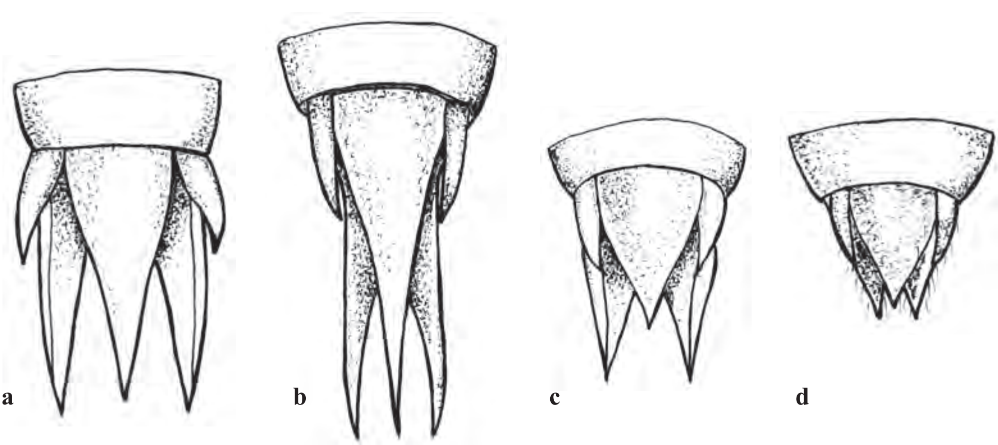
Figure 78: *Orthetrum cancellatum* head.



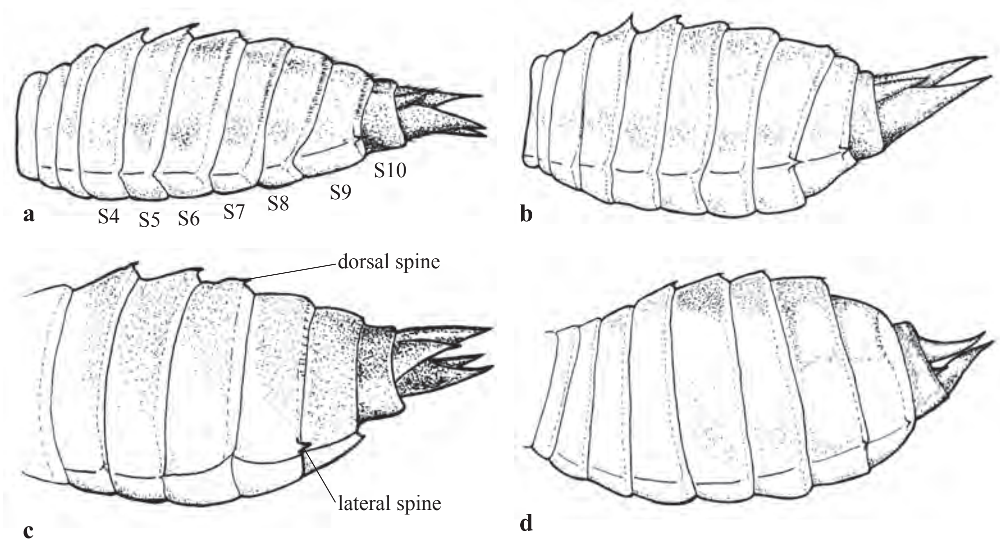
Figures 79a-c: *Orthetrum* Labial masks. **a**: *O. cancellatum*; **b**: *O. brunneum*; **c**: *O. coerulescens*.

Table 19. Features of *Orthetrum cancellatum*, *O. trinacria*, *O. coerulescens anceps*, and *O. brunneum*.

Body length	Labial palp	Prementum	Abdominal mid-dorsal spines	Abdominal lateral spines	Epiproct	↴
21 - 29 mm	8 (rarely 7) setae. Distal margin with 6 inconspicuous crenations (Gerken &Sternberg, 1999) (Fig. 79a)	3 long, 3 medial, 7 -12 (16) short, barely distant section	Found on S3 - S6.Small on S3. None on S7 - 8 (Fig.81a)	Small on S8 - 9 (Fig.81a)	Shorter, with length: breadth ratio = 2 or smaller (Fig. 80a)	***O. cancellatum***
25 - 30 mm	Data not available	Data not available	S3 - 6 S7 very reduced, none on S8 (Fig.81b)	Present on S8 - 9 (Fig.81b)	Longer, with length: breadth ratio = 2.5 + (Fig. 80b)	***O. trinacria***
17 - 23 mm	3 (rarely 4-6) setae (Fig. 79b)	Distal margin rounded. Per side 2 long, 4 - 7 short and mesial field of several rows of very small spiniform setae (20 mm)	All segments (very small on S7) (Fig.81c)	Very small on S8 - 9 (Fig.81c)	Shorter with length: breadth ratio = >1.5 (Fig. 80c)	***O. coerulescens anceps***
20 - 25 mm	5 - 7 setae (Fig. 79c)	2 - 3 long setae per side not distant from short ones.	Absent (Fig.81d)	Absent on S8 - 9 (Fig.81d)	Shorter with length: breadth ratio = >1.5 (Fig. 80d)	***O. brunneum***



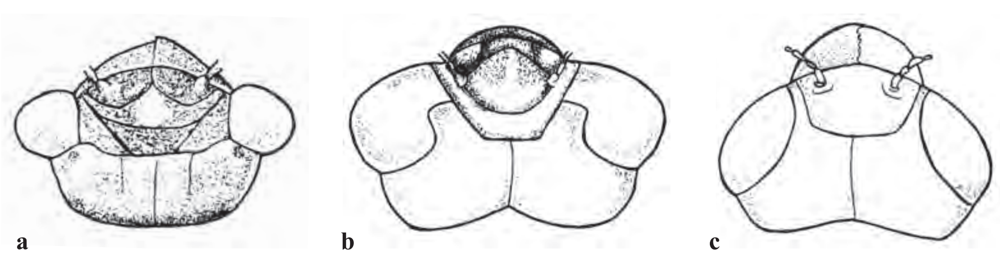
Figures 80a-d: *Orthetrum* caudal pyramids (a-c modified after Carchini, 1983) showing length:breadth ratio of epiproct. **a**: *O. cancellatum* - ratio: =2; **b**: *O. trinacria* - ratio: =2.5+; **c**: *O. coerulescens* - ratio: >1.5; **d**: *O. brunneum* - ratio: =>1.5.



Figures 81a-d: *Orthetrum* abdomens lateral view. **a**: *O. cancellatum*; **b**: *O. trinacria*; **c**: *O. coerulescens*; **d**: *O. brunneum*.

Table 20. Features of the Libellulid genera other than *Orthetrum* (i.e. *Crocothemis*, *Sympetrum*, *Trithemis* and *Selysiothemis*).

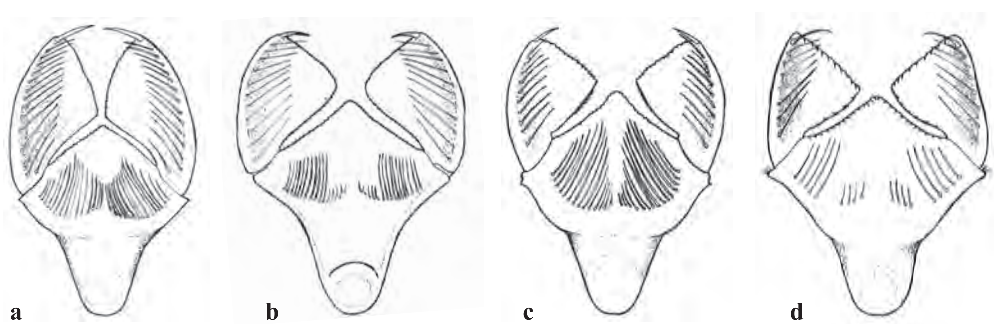
Feature	Libellulid genera other than *Orthetrum*
Body shape and size	In most cases smaller and more slender.
Head (Fig. 82a-c)	More rounded than in *Orthetrum*, eyes larger and more prominent.
Hairs/ setae	Body covered with a small number of tough hairs
Eyes	Large and projecting laterally frontally appear to touch labial mask.
Post-ocular lobes	Reduced
Thorax	Narrow – pronotum is half as wide as head
Legs	Longer and more slender. femora straight.
Abdomen	Tapers abruptly between S9 and S10.
Larval habits	Active and mobile usually move around aquatic vegetation.



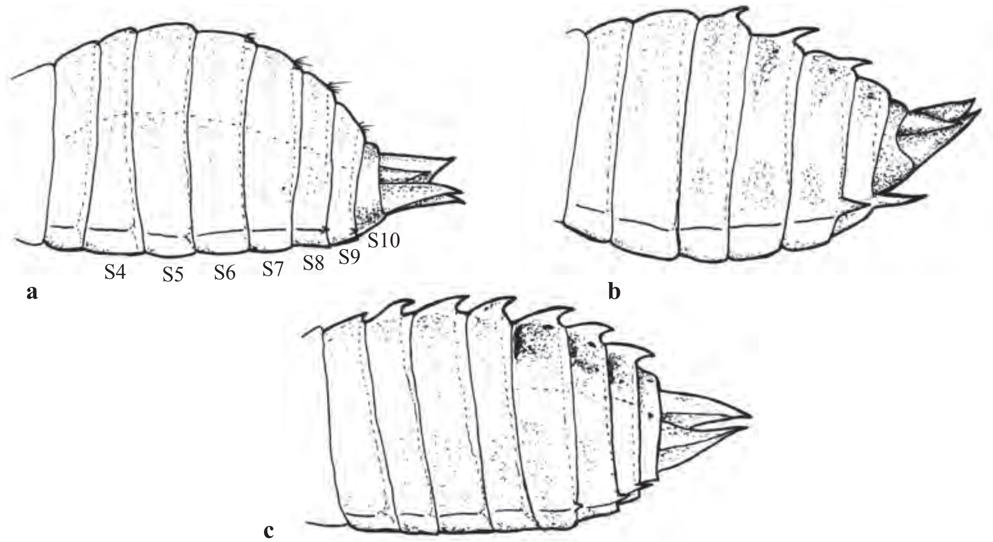
Figures 82a-c: Heads. **a**: *Sympetrum*; **b**: *Trithemis*; **c**: *Selysiothemis*.

Table 21. Features of *Sympetrum fonscolombii*, *S. striolatum, Crocothemis erythraea*, *Trithemis annulata* and *Selysiothemis nigra.*

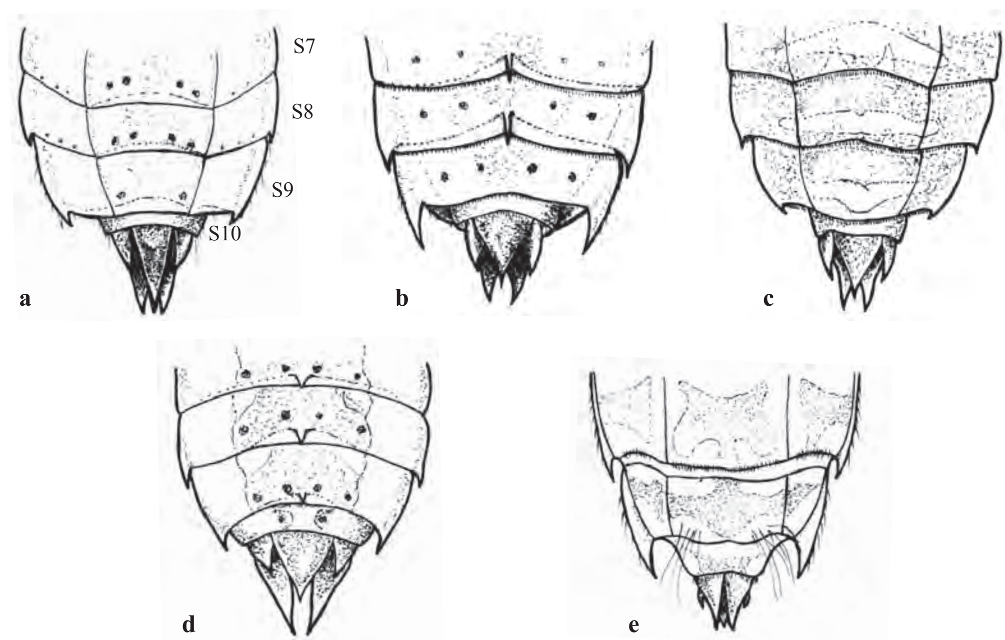
Distinctive features	Body length	Abdominal mid-dorsal spines	Lateral spines	↴
Labial palp with 12-14 setae (Fig. 83a). Abdomen striped	15-18 mm	Absent and with no setae (Figs. 84a, 85a)	Very short on S9 and rudimentary on S8 (Figs. 84a, 85a)	***S. fonscolombii***
Labial palp with 11 setae (Conci & Nielsen, 1956) . Prementum with 14-16 setae on each side 10-11 being long (Fig. 83b)	15.5-18 mm	Slightly curved in profile on S5-S8; rudimentary on S4 (Figs. 84b, 85b)	Present on S5-S8; rudimentary on S4 (Figs. 84b, 85b)	***S. striolatum***
Labial palp with 10-11 setae . Prementum with 2 rows of 15-16 setae each (Fig. 83c)	18-19 mm	Absent replaced by setae on distal margin of S8 (Fig. 85c)	Short spines on S8-9 (Fig. 85c)	***C. erythraea***
Labial palp with 7 setae. Prementum with 18 setae on each side (Fig. 83d)	Approx 17 mm	Well developed on all abdominal segments (Fig. 84c, 85d)	Present on S8-9 (Fig. 84c, 85d)	***T. annulata***
Labium with at least 9 setae (Askew, 2004). Labium in resting position reaches to the level of the middle coxae	20 mm	Present on S3-8. Distal margin of S8 with setae (Carchini, 1983) (Fig. 85e)	Present on S8-9 (Fig. 85e)	***S. nigra***



Figures 83a-c: Labial masks. **a**: *Sympetrum fonscolombii*; **b**: *Sympetrum striolatum*; **c**: *Crocothemis erythraea*; **d**: *Trithemis annulata.*



Figures 84a-c: Abdomens lateral view. **a**: *Sympetrum fonscolombii*; **b**: *Sympetrum striolatum*; **c**: *Trithemis annulata.*



Figures 85a-e: Abdomens dorsal view. **a**: *Sympetrum fonscolombii*; **b**: *Sympetrum striolatum*; **c**: *Crocothemis erythraea*; **d**: *Trithemis annulata*; **e**: *Selysiothemis nigra* ventral view (modified after GERKEN & STERNBERG, 1999).

DISCUSSION

Odonate impact on humans

Due to the fact that odonates usually prey on organisms which are most common at one particular time, they do not tend to affect specific populations of individuals. It is therefore argued (e.g. Corbet, 2004) that dragonflies may have no great impact on humans. However a number of recent scientific studies showed that odonates have been proved useful to humans.

One such study by Sebastian *et al.* (1990) has revealed that in South-East Asia larvae of *Crocothemis servilia*, a species which is closely related to the locally occurring *C. erythraea*, proved to be an effective measure to control numbers of yellow fever mosquitos, *Aedes aegyptus*, notorious vector of chikungunya and yellow fever as well as dengue fever viruses. No studies investigating possible predator-prey relationships between dragonflies and the Asian tiger mosquito *Aedes albopictus*, a recently introduced alien species to the Maltese Islands have been carried out to date.

It has already been discussed on pg. 36 that recording the distribution of odonate species can be used to monitor climatic change. Both Riservato *et al.* (2009) and Balzan (2012) claim that odonates can be quite effectively used to monitor the quality of freshwater habitats. Riservato *et al.* (2009) argue that this can be done because: (i) their distribution can easily be monitored with the aid of volunteers, which can contribute data that can be pooled, and (ii) being large and colourful, they can generate interest and can be used as "*ambassadors for freshwater conservation*" and raise awareness for freshwater habitats with the general public.

Human impact on odonates

Humans leave a dramatic impact on natural ecosystems, including those where odonates occur. Effects can be both negative and positive.

Habitat loss

According to Riservato *et al.* (2009) some southern Mediterranean countries, including the Maltese Islands, are using more than their renewable water resources (e.g. fossil water). About 64% of Mediterranean freshwater is used for agriculture. Such practices are counterproductive to odonate species, as they may not allow time for larvae to complete their life cycle. Rapid local urbanization and reclaiming of natural land for agricultural purposes make up the most influential negative impact humans have on local odonates. According to Wiligalla & Fartmann (2012), urbanisation has an adverse effect on the species diversity of Odonata, probably because of the decrease in habitat quality and number of available water bodies found in city centres resulting in a low species richness of Odonata.

Introduction of alien species

A number of alien species introduced in habitats frequented by odonates and their larvae affect these insects negatively. Some may be found in public and private gardens as well as in artificial related habitats, such as water reservoirs. Moreover, some species are occasionally bought as pets and subsequently disposed of into valleys and natural ponds, where they slowly become established. Such species not only prey on adult odonates, but may also destroy the pre imaginal stages.

Figures 86a-d: Alien species which affect odonates negatively. **a**: Levant Water Frog (*Pelophylax bedriagae*); **b**: goldfish (*Carassius auratus*); **c**: mosquitofish (*Gambusia* sp.); **d**: Great Reed (*Arundo donax*).

Typical alien species include goldfish (*Carassius auratus* - Fig. 86b), that devour larvae and also compete with them for food and mosquitofish (*Gambusia* sp. - Fig. 86c), that have been observed to collect all eggs deposited by odonates[45]. The Levant Water Frog (*Pelophylax bedriagae* - Fig. 86a) a species that has established itself on ponds such as that of Sarraflu, Gozo, feeds on larvae (Sciberras & Schembri, 2006). The Red-eared Terrapin (*Trachemys scripta elegans*), a popularly grown species in garden ponds and water features can also feed on ova, larvae and freshly emerged adults.

The Great Reed, *Arundo donax* (Fig. 86d) a widely distributed alien plant species, seems to affect the local occurrence of species such as *Crocothemis erythraea* and *Ischnura genei* negatively, probably because being a large invasive plant, it tends to add shade to water bodies, and also changes accessibility to water (Balzan, 2012).

Other negative practices

According to Riservato *et al.* (2009), habitat destruction, degradation, pollution and mismanagement of water bodies are significant threats to dragonflies in the Mediterranean Basin. Overuse of water

[45] Though mosquito fish can also serve as a source of food to larger larvae, particularly those of *Anax* species.

in valley courses for irrigation, dumping of garbage and human disturbance in valleys, as well as indiscriminate use of pesticides pose a general serious pollution problem to local valley ecosystems. Riservato *et al.* (2009), also argue that climate change will be one of the most important threats to dragonflies in the Mediterranean, namely because of increased water demand accompanied by a lower level of precipitation. This will result in the desiccation of brooks, a habitat on which many endemic species are dependent. Locally this may already be affecting species which are confined to moving water bodies such as *Orthetrum brunneum*.

Conservation

The preservation of aquatic habitats is essential for local odonates. Riservato *et al.* (2009) recommend a number of practices to promote conservation of odonates, namely: legislation; research; monitoring; population management; and land acquisition or control.

An official Red List was adopted and published in 1989 by the Government of Malta. This is based on the old IUCN criteria and is currently being revised by the Malta Environment and Planning Authority (MEPA). This document lists two dragonfly species, *Ischnura genei* as it is only found on some Mediterranean Islands, and *Orthetrum brunneum*, because of its restricted distribution within the Maltese Islands. The selection of species to be included in the 1989 Red Data Book was mostly based on expert opinion. The current data being assessed by MEPA is based on a combination of all the above, although this varies from species to species. A number of Odonata species are also protected under the 2006 Flora, Fauna and Natural Habitats Protection Regulations, (*Regolamenti ta' l-2006 dwar il-Protezzjoni tal-Flora, Fawna u Ambjenti Naturali*). This document, based on the EC Habitats Directive (1992), lists *Anax parthenope, Orthetrum trinacria* and *O. brunneum,* as being "*Species of National Interest in need of Strict Protection*". Although these species were chosen to be granted protection, this study has shown that, apart from *Orthetrum brunneum* the other species are well established and currently not under threat. Given a choice, the species which should be given some form of protection should include those which have shown decline in the past couple of decades, for example *Orthetrum cancellatum* and *Sympetrum striolatum,* as well as those species which are localised or which show a sporadic appearance mainly *Anax ephippiger.*

Apart from protecting species by legal means, it is also important that species are monitored periodically. According to Riservato *et al.* (2009), many European countries have no formal schemes for monitoring dragonfly species. This is, in fact, the case for the Maltese Islands.

Riservato *et al.* (2009) recommend that up-to date information on distribution of species is needed in order to use odonates as quality indicators. Perhaps campaigns which increase awareness on the odonates of the Maltese Islands could be one way to establish a number of volunteers that can collect and pool such data for future reference. This could in turn facilitate the monitoring of local aquatic biotopes, in nature reserves as well as other habitats that encourage breeding of the species.

Riservato *et al.* (2009) also claim that one of the future challenges, is to improve monitoring so as to increase the quantity and quality of the information available. Another possible challenge for the future could involve the devising of action plans which promote better management of local land resources and the preservation of local aquatic habitats, in order to preserve the odonates of the Maltese Islands.

ACKNOWLEDGEMENTS

I would first of all like to thank Dr K.D.B. Dijkstra, from the Department of Entomology, National Museum of Natural History Naturalis, Leiden, The Netherlands, who took the time and trouble to review the first draft edition of this work and also offered me advice on the study of odonates.

I would also like to thank Dr Louis F. Cassar, Mr Denis Magro, Mr Paul Sammut, Mr Anthony Seguna and Mr Arnold Sciberras who allowed me to consult their collections or records, as well as to Mr John Borg, curator of the National Museum of Natural History of Malta (NMNH), Mdina, who allowed me access to the specimens of the NMNH collection as well as to those from the Guido Lanfranco Collection. I would also like to thank Dr Natalino Fenech who provided me with information and photographic material on predatory birds (Fig. 26f), Mr Victor Falzon, who offered advice on the Maltese vernacular names of some of the species; Mr Mark Gauci who allowed me to carry out observations at the Simar Nature Reserve during 2013 and Mr Charles Coleiro who saw to my requirements during the visits at the Reserve.

Grateful thanks also go to Mr Alfred Gatt Floridia who was very obliging and promptly sent all the photographic material I needed (Figs. 2, 3, 11d, 26e, 30a, 37a, 46b, 47, 50a, 53a, 58c, 62b,c-d,f-g, 64a, 66a-c), to Mr Bernd Kunz who, apart from offering me support through his correspondence, supplied me with the photographs of rare and expected vagrant species (Figs. 32, 34a, 48a-b, 51a-b, 52, 59a,c, 66b, 69, 70a-b, 71a-f, 72a-h), to a number of contributors of photos, namely to: Mr Joe Attard (Figs. 28c, 64b); Mr Guido Bonnett (Figs. 31, 37d, 58e); Mr Denis Cachia (Figs. 35b, 38a.); Mr Gottfried Catania (Figs. 14, 20b, 58d, 62h); Mr. Steve Cilia (Fig. 26d.); Mr Juan Ellul Pirotta (Fig. 26c); Ms Jacqueline Galea (Fig. 26a.); Mr Raymond Galea (Fig. 46c); Mr Charles Gauci (Fig. 26b); the late Mr. Daniel Grand (Fig. 68a); Mr Arnold Sciberras (Figs. 9a, 11c, 23c, 24a-d, 25a, c, 30b, 35a, 38c,d, 40a-b, 44a, 45b-c, 53b, 58f, 64d-e, 86b-c); Mr Torsten Ruf (Fig. 34b); and Mr. Joe Sultana (Fig. 46a).

Thanks also go to Dr David Mifsud, without whose constant support and encouragement this work would have never seen the light of the day. I thank the graphic designer, Mr. Daniel Spagnol, who patiently bore with me for many long hours which ran into the small ones in order for the final finishing touches of this work to be completed, and finally to my wife Geraldine, and children Nico and Louisa, who have been rather patient with me while I was busy with my work for all this time.

GLOSSARY

The following is a list of biological and odonate-related technical terms that are found throughout this work, as well as their definitions and, where applicable, abbreviations.

Abdomen: hind section (or tagma) of the insect, in odonates it is divided into ten segments referred to as S1 (segment adjacent to thorax) - S10 segment at posterior tip of abdomen.
Agonistic behaviour: aggressive or defensive actions, such as fleeing or fighting, brought on by the interaction between conspecific individuals, usually as a consequence of fighting over food resources or for a mate.
Anal appendages: found at tip of abdomen, in males used to grasp females by the pronotum (in zygopterans) or by the head (in anisopterans) during mating consisting of an upper (superior) pair, and an inferior pair (in zygoptera) or an inferior single (in anisoptera) appendage.
Anal loop (anal field): a field of cells in anisopterans surrounded by a vein that loops round this field from the posterior corner of the triangle and ending close to the wing base.
Anal triangle: a series of cells on the hindwing shaped in a downward pointing triangle. The number of cells within a triangle are representative of certain species, and is used as a determining factor for identifying individuals.
Anal vein: the hindmost 5th main vein of the odonate wing.
Anisopteran: insects belonging to the Suborder Anisoptera referred to as dragonflies.
Antehumeral stripe: pale stripes on the dorsal anteriormost part of the thorax (mesepisternum). Can be diagnostic in some species.
Antclypeus: see clypeus.
Anterior lamina: front part of the secondary genitalia in males. Its shape varies per species and can be used for identification purposes.
Andromorph: a specimen with male resembling features e.g. coloration.
Ante nodal cross veins (A_x): cross veins found on anterior part of the wing in the region between the wing base and node.
Arculus: a thick crossvein which joins the radial and medial vein.
Auricles: a small lobe found on S2 of the male abdomen in some anisopteran species, namely Gomphidae, some Aeshnidae and some Corduliidae. Thought to serve to guide the female genitalia to the male prior to sperm transfer.
Carina: a dorsal ridge on the thorax of the odonate.
Cells: spans of wing surrounded by veins.
Costal vein (costa): anteriormost main vein found on leading edge of the wing, spanning all the way from base to tip.
Coxa: upper leg segment which connects leg to thorax.
Cubital vein (Cu): third main vein in wing which emerges from wing base and terminates at the middle part of the wing.
Cubital cross veins (Cux): cross veins joining cubital and anal veins from wing base to the triangle
Clypeus: middle region of the face of the odonate between frons and labrum. It is made up of the anterior (lower) secton, or antclypeus and the posterior (upper) section, or post clypeus.
Discoidal cell: a region of cells in the wing of an odonate near wing base. Because of differences in venation between dragonfly Suborders, it is known as the quadrilateral in zygopterans and as the hypertriangle plus triangle in anisopterans.
Discoidal field: a number of (usually rows of) cells which extend from the triangle to the wing border between cubital and anal veins. Can be diagnostic in identifying some libellulid species.
Distal: away from the body (antonym proximal).

Ecdysis: a stage where arthropod larvae or larvae shed their exoskeleton as it becomes too small. The process is also known as moulting.
Emergence: stage in the odonate life cycle when the final instar moves away from water moults and becomes an adult.
Episternum: skeletal plates cover the upper and lateral parts of the synthorax. They are known as the mesepisternum, and the metepisternum. They are divided by humeral sutures (see: Humeral suture).
Epimeron: skeletal plates cover the lower parts of the thorax.
Exopterigota: insects which have larval stages that are similar to adults except for being smaller, are not capable of reproducing and have no or vestigial wings as the larva progresses to adulthood.
Exuviae: cast larval skins. In odonates, the final instar exuviae are most likely to be found on pond vegetation as the aquatic larva climbs up onto dry land to change into the terrestrial adult.
Euriyceous: species which are able to frequent broad variety of ecological living conditions regarding a single factor, in this case lentic and lotic ewater bodies.
Endophytic: species that lay eggs in floating pond debris or vegetation. Odonate species that oviposit endophytically usually have elongated ova, while females are equipped with an ovipositor.
Exophytic: species that freely lay eggs in the water. Eggs of these type of species are usually spherical in shape.
Femur: upper leg segment which joins basally to the coxa (via the trochanter) and apically to the tibia.
Frons: upper part of face situated between the eyes and the clypeus.
Genitalia: reproductive organs. In males the primary genitalia found at the tip of the abdomen and produce sperm, this is transferred to the secondary genitalia which are found on S2. These will transfer sperm to the female. Female genitalia produce eggs and then deposit them in water. In endophytic species they have a fully functional ovipositor, but in exophytic species this is reduced to form a vulvar scale which serves as a “chute” that releases the eggs in the water.
Genital lobe: hind part of male secondary genitalia.
Guarding behaviour: a behaviour which is carried out by males of some species while females are ovipositing in Order to ward off any other males which would attempt to mate with the female. Some species guard females at a distance (non-contact guarding) while others keep holding the female by the anal appendages while she is ovipositing (contact guarding).
Gynomorph (heteromorph): a specimen with the appearance and body colour which is distinctly different from males (typically dull).
Hamule: middle part of the male secondary genitalia. The structure contains a hook which is used to grasp the female from the neck or head during and after copulation. The shape of this structure varies per species and can be used to identify the specimen.
Hemimetabulous: arthropod species that undergo an incomplete life cycle where larval stages resemble adults except for size, presence of wings, and sexual maturity.
Homeostatic functions: body functions that keep the body state constant. e.g. excretion, temperature control, etc.
Humeral sutures: joints in the thorax between the anterior episternal plates. Their colour is diagnostic of some species.
Hypertriangle plus triangle: see discoidal cell.
Labial mask: a modified labial structure found on the frontal part of the head in odonate larvae and used to catch prey by means of a catapulting mechanism. Its shape varies per odonate family. Consisting of a prementum and labial palpi which fold over.
Labial palp: upper segment of labial mask in larvae attached proximally to the prementum. Is movable and used to capture prey and direct it towards the mouth. Usually has a number of features and setae that are distinctive of some species.

Labium: a lower lip-like structure which covers a set of teeth like mandibles.
Labrum: an upper lip-like structure which covers a set of teeth like mandibles.
Lamellae: gills or high surface area structures which have a gaseous exchange function. In odonates, they are external in zygopteran larvae and internal in anisopteran larvae.
Lentic water bodies: constantly flowing water bodies such as streams frequented by a few local species.
Lotic water bodies: standing water bodies. Frequented by the majority of local species.
Macrophytes: vegetation which is associated with waterside habitats.
Mandibles: insect mouthparts usually fashioned to aid the insect in processing food before ingestion. Odonate mouthparts are adapted to chew and crush pieces of prey.
Maturation period: the time where adults are still not sexually mature, and may spend their time diepersing and hunting away from water bodies.
Medial vein: vein which is found in the middle of the wing.
Medial supplemental vein (mspl): vein which lies across wing length found at the centre of the anisopteran wing below the wing node.
Medial space: area in wing between the wing base and arculus usually without cross veins usually found in most Anisoptera.
Membranule: pigmented, usually triangular shaped region of wing closest to wing base. More prominent in hindwing.
Metapleural suture: joints in the thorax between the posterior episternal plates. Their colour is diagnostic of some species.
Nodus (node or wing notch): found in all living anisopterans and most zygopterans, but absent in extinct species.
Obelisk position: a posture assumed by many odonates where the tip of the abdomen is pointed in the direction of the sun, thus as little of the body as possible absorbs heat energy from the sun. This posture is assumed during hot conditions to prevent overheating.
Ocellus (pl. ocelli): light sensitive organ with lens usually found in top of head between or infront of the compound eyes.
Occiput: posterior portion of the head, behind the eyes. In *Anax parthenope* females, two tubercles are found growing out of his structure.
Odonata: toothed insects. Include dragonflies (Anisoptera) and damselflies (Zygoptera)
Ommatidia: eye components that make up the large compound eyes.
Ovipositing: egg laying.
Ovipositor: long tubular structure found in endophytic species, used to bore a tunnel in vegetation, or pond related debris in Order to deposit eggs. Present in Zygoptera and Aeshnidae.
Palaeopterous wing mechanism: primitive wing mechanism found in odonates and ephemeropterans that does not allow for the wings to fold flat over the body.
Petiole: or stalk. A narrowing of the wing as it fuses with the thorax. Narrowing is particularly prominent in zygopterans.
Post nodal cross veins (P_x): cross veins found between veins situated between node and wing tip.
Post ocular spots: brightly coloured spots founs at the back of the head of Coenagrionidae. Can be distinctive of species.
Post clypeus: see clypeus.
Prementum: lower part of labial mask which is fired at prey is attached to the labial palp apically. The number of setae present may be distinctive of the species.
Prolarva: first stadium of larva immediately after this hatches. Will usually moult within a short period of time into the first instar larva.
Pronotum: a shield - like structure found at the top of the prothorax. Its shape is diagnostic of some species. Male zygoperans clasp the females from the pronotum during tandem pairing.

Protists: unicellular organisms which are mostly aquatic. They constitute an important part of the odonate larval diet during the early stages of larval development.
Proximal: towards the body (antonym distal).
Prothorax: anteriormost segment of the thorax which joins with the head and posteriorly with the synthorax. The anterior pair of legs attached to this section.
Pruinescence (pruinosity): powdery blue pigmentation that develops in some adult male and old female libellulid species.
Pterostigma (pt): or wing spot, a coloured spot found on each wing in odonates. Present in all anisopera and most zygoptera, but absent in extinct fossil records.
Quadrilateral: see discoidal cell.
Radial supplemental vein (rspl): vein which lies across wing length found at the centre of the anisopteran wing from wing node to wing tip.
Saddle: a widened area on the first two to three segments of the abdomen in some aeshnids (namely in Anax species). It is usually blue, and is not always distinct.
Setae: hairs found on body and labial mask of larvae. Their occurrence and quantity is distinctive of species.
Sternites: lower skeletal plates covering ventral part of body.
Secondary genitalia (accessory genitalia): a set of genital organs situated on the first segments of the abdomen, closest to the thorax. Used in sperm transfer to females during copulation.
Subnodal vein (subnode): the oblique vein which is situated below the nodus in the wing.
Subcostal vein: second main vein emergin from wing base and ending at wing node.
Sutures: grooves which separate sbody segments found in face and on sides of thorax.
Synthorax: posterior part of thorax connsisting of the meso and metathorax which in odonates seem to be fused. A pair of wings and pair of legs is attached to each segment.
Tandem pairs: male and female specimens paired up in flight prior to fertilization and in some species, during ovipositing.
Tail-light: colour markings in specific points on the posterior segments of the abdomen of some zygopterans. In *Ischnura* they are found on dorsally, while in *Calopteryx* they are found ventrally.
Tarsus (pl. tarsae): small terminal leg segments leg attached basally to the tibia.
Teneral phase: newly emerged individuals which are pale, soft and with shiny wings. They will develop the pigmentation of the adult with time.
Tergites: upper skeletal plates covering dorsal part of body.
Tibia: lower part of the leg which joins basally with the femur and apically to the tarsae.
Triangle: see discoidal cell.
Trochanter: connection between coxa and femur.
Trophic level: feeding levels in an ecosystem. Dragonflies and damselflies are carnivores meaning that they occupy one of the high feeding levels in ecological feeding systems, where the bottom levels include plants (producers) and on top of those herbivores.
Vulvar scale (vulvar plate): a “chute” like structure found in S8 of females of exophytic species. It is used to deposit eggs directly in water.
Vertex: raised structure on topmost part of head enclosed by ocelli.
Vulvar spine: spine on ventral side of S8 in some zygopteran females. May be distinctive of some species.
Zygopteran: insects belonging to the Suborder zygoptera referred to as damselflies.

REFERENCES

Azzopardi, A. (2002) *A New Geography of the Maltese Islands*. Progress Press Valletta, Malta, 375 pp.

Abbott, J.C. (2005) *Dragonflies and Damselflies of Texas and the South-Central United States*. Princeton, Princeton University Press, 424 pp.

Askew, R.R. (2004) *Dragonflies of Europe* . 2nd revised edition. Essex, Harley books Ltd., 363 pp.

Balzan M.V. (2008) The distribution of *Orthetrum trinacria* Selys, 1841 and *Trithemis annulata* Palisot de Beauvois, 1807 in the Maltese Islands (Odonata: Libellulidae). *Bulletin of the Entomological Society of Malta*, **1**: 91-96.

Balzan, M.V. (2012) Associations of dragonflies (Odonata) to habitat variables within the Maltese Islands: A spatiotemporal approach. *Journal of Insect Science*, **12**: 87 [available online: insectscience.org/12.87 and accessed on 16.xi.2012].

Bechly, G. (2003). The Phylogenetic Relationships of the Three Extant Suborders of Odonata. *Entomologische Abhandlungen*, **61**(2): 128-130.

Bechly, G. & Poinar, G. (2013) *Burmaphlebia reifi* gen. *et* sp. nov., the first anisozygopteran damsel-dragonfly (Odonata: Epiophlebioptera: Burmaphlebiidae fam. nov.) from Early Cretaceous Burmese amber. *Historical Biology*, 2012, 1-5.

Bernard, R. & Ivinskis, P. (2004) *Orthetrum brunneum* (Fonscolombe) a new dragonfly species in Lithuania (Odonata: Libellulidae). *Acta Zoologica Lituanica*, **14** (3): 31-36.

Boudoit J.,-P., Kalkman, V.J., Azpilicueta Amorìn M., Boganović, T., COrdero Rivera A., Degabgiele, G., Dommanget, J.-L., Ferreira, S., Garrigós, B., Jović, M., Kotarac, W., Lopau, M., Marinov, Mihoković, N., Riservato, E., Samraqui B. & Schneider W. (2009) Atlas of the Odonata of the Mediterranean and North Africa. *Libellula*, **9** (Supplement): 1-256.

Brooks, S. (2002) *Dragonflies.* The Natural History Museum London, 96pp.

Bugeja, P. (1999) *Kelmet il-Malti Dizzjunarju*, Floriana, Associated Group News Ltd., 513 pp.

Busuttil, E. (1941) *Damm il-Kliem (Kalepin)*, *Malti - Ingliż*, Valletta, Giov Muscat, 519 pp.

Carchini, G. (1983) *Odonati* - Consiglio Internazionale delle ricerche AQ/l/198 - Guide per il riconoscimento delle specie animali delle aque interne ltaliane -' Roma, 79 pp.

Cham S. (2010) *Field guide to the Larvae and Exuviae of British Dragonflies*. British Dragonfly Society, Peterborough, UK. 152pp.

Cham, S. (2007) *Field Guide to the larvae and exuviae of British Dragonflies: Volume 1: Dragonflies (Anisoptera)*. Peterborough, UK. British Dragonfly Society. 76 pp.

Cham, S., (2009) *Field Guide to the larvae and exuviae of British Dragonflies: Volume 2: Damselflies (Zygroptera)*. Peterborough, UK. British Dragonfly Society. 76 pp.

Chetcuti, D., Buhagiar, A., Schembri, P.J. & Ventura, F. (1992) *The Climate of the Maltese Islands: a review*. Malta University Press. 108 pp.

Cilia, J.L. (1972) An Entomologists' Diary. *The Maltese Naturalist*, no.3.

Conci, C. & Nielsen, C. (1956) - *Odonata* - Officine Grafiche Calderini Bologna. ix + 298 pp.

Corbet, P. (1962). *A Biology of Dragonflies.* Witherby Ltd., London, 247pp.

Corbet, P. (2004). *Dragonflies, Behaviour and Ecology of Odonata*. Essex, UK, Harley Books Ltd. 363 pp.

Corbet, P. & Brooks S. (2008) *Dragonflies:* A new Naturalist Library. Harper Collins Publishers, London. 454pp.

Corso, A., Janni, O., Pavesi, M., Sammut, M., Sciberras, A. & Vigano, M. (2012) Annotated checklist of the dragonflies Insecta Odonata) of the islands of the Sicilian Channel, including the first records of *Sympetrum sinaiticum* (Dumont, 1977) and *Pantala flavescens* (Fabricius, 1798) for Italy. *Biodiversity Journal*, **3** (4**)**: 459-478.

Cowley, J. (1940) A List of the Odonata of the Islands of the Western Mediterranean Area. *Proceedings of the Royal Entomological Society of London* (B) **9**: 172-178.

d'Aguilar, J., Dommanget, J-L. & Prechac, R. (1985) *A.field guide to the Dragonflies of Britain, Northern Europe, and North Africa*. London - William Collins Sons & Company Ltd. 336 pp.

De Knijf, G. & Anselin, A. (2010) When south goes north: Mediterranean dragonflies (Odonata) conquer Flanders (Northern Belgium) (pp. 141-154). In: Ott, J. [ed.], *Monitoring climatic change with dragonflies.* Pensoft Publishers, Sofia, Bulgaria. 286 pp.

Degabriele, G. (1992) *Aspects in the ecology of Maltese Odonata*, Unpublished B.Ed. (Hons.) dissertation, University of Malta.

Degabriele, G. (2008) An Annotated Inventory of the Odonata of Guido Lanfranco housed in the National Museum of Natural History of Mdina in Malta. *Bulletin of the Entomological Society of Malta*, **1**: 85-89.

Dijkstra, K.D.B., & Kalkmann V.J. (2012) Phylogeny, classification and taxonomy of European dragonflies and damselflies (Odonata): a review. *Org. Divers. Evol.* DOI 10.1007/s13127-012-0080-8.

Dijkstra, K.D.B., & Lewington, R. (2006) *A field guide to the Dragonflies of Britain and Europe*. Dorset, British Wildlife Publishing, 320pp.

Doucet, G. (2010) *Clé de détermination des Exuvies des Odonates de France*, Société Française d' Odonatologie, Bois-d' Arcy, 64 pp.

DOI (2006) Legal Notice 311 of 2006. Regolamenti ta' l-2006 dwar il-Protezzjoni tal-Flora, Fawna u Ambjenti Naturali. The Malta Government Gazette Supplement, Section B no.18, 006, 7th December, 2006.

Ebejer, M.J., Degabriele, G. & Sciberras, A. (2008) An annotated checklist of Odonata of the Maltese Islands, with evidence for a recent influx of species. *Libellula*, **27** (1/2): 133-145.

FAO (2006) *Malta water resources review.* Food and Agriculture Organisation of the United Nations, Rome.

Falzon, V. (2007) Żewġ Mazzarelli Godda! *Huttafa*, **82**: 2.

Fraser, F. C. (1957) *Odonata: Handbooks for the Identification of British Insects.* Vol.**1** Part 10: Royal Entomological Society of London. 49 pp.

Gerken, B. & Sternberg, K. (1999) The exuviae of European Dragonflies/ *Die Exuvien Europäscher Libellen*. Huxaria Drukerei GmbH, Hoxter. 354 pp.

Gauci, C. & Sciberras, A. (2010) First records of *Orthetrum chrysostigma* (Odonata, Libellulidae) Burmeister, 1839, from the Maltese Islands. *The Central Mediterranean Naturalist*, 5(**2**): 78-80.

Gonseth, Y. & Monnerat, C. (2003) *Recent changes in distribution of dragonflies in Switzerland (Odonata)*. Proceedings of the 13th International colloquium of the European Invertebrate Survey, Leiden, 2-5 September 2001: 23-31.

Kalkman, V.J., Boudoit J.,-P., Bernard, R., Conze K., -J., De Knijf, G., Dyatlova, E., Ferreira, S., Jović, M., Ott, J., Riservato, E. & Sahlén, G. (2010) *European Red List of Dragonflies*. Publications Office of the European Union, Luxembourg. 27 pp.

Keen, D. (1977) *Collecting and studying Dragonflies.* Amateur Entomological Society Leaflet no.12 – revised edition. 24 pp.

Koch, K. (2006) Effects of male harassment on females' oviposition behaviour in Libellulidae (Odonata). *Internatonal Journal of Odonatology*, **9**(1), 71-80.

Kulijer D., Baker R.A. & Zawal A. (2012) A preliminary report on parasitism of Odonata by water mites from Bosnia and Herzegovina. *Journal of British Dragonfly Society,* **28 (**2): 92-100.

Lanfranco, S. (1990) *The Ecology of Freshwater Rockpools in Malta* - Unpublished B.Ed. (Hons) Dissertation, University of Malta.

Lempert, J. (1997) Die Einwanderung von Sympetrum fonscolombii (Selys) nach Mitteleuropa im Jahre 1996 (Anisoptera: Libellulidae). *Libellula*, **16**: 143-168.

Liddell, H.J. & Scott, R. (1980) *Greek-English Lexicon, Abridged Edition*. Oxford University Press, Oxford, UK. 812pp.

MARTENS A., EHMANN H., PEITZNER G., PEITZNER P. & WILDERMUTH H. (2008) European Odonata as hosts of *Forcipomyia paludis* (Diptera: Ceratopogonidae). *International Journal of Odonatology* **11** (1):59-70.

MCLACHLAN, R. (1899) Remarque sur quelques odonates de l'Asie Mineure meridionale comprenant une espece nouvelle pour la faune palearctique. *Annales de la Societe Entomologique de Belgique*.

MILLER, P.L. (1995) *Dragonflies.* Naturalist's Handbook 7. Richmond Publishing, 118 pp.

Minnesota Odonata Survey Project (n.d.). Surveys: Volunteer Manual. (adapted from the Wisconsin Odonata Survey, written by Bob DuBois). [Available on-line: http://www.mndragonfly.org/journal.html. Accessed 19.xi.2012].

NSO (2006) *Environmental Statistics 2006*, National Statistics Office. 72 pp.

NSO (2010) *Estimating volume of water usage for irrigation in Malta 2009*. National Statistics Office. 26 pp.

NELSON, B., THOMPSON, R. & MORROW, C. (2000) *Dragonflies of Ireland* [available on-line http://www.habitas.org.uk/dragonflyireland/430683.htm. Accessed 16.xi.2012].

OTT, J. (2001) Expansion of Mediterranean Odonata in Germany and Europe – consequences of climatic changes (pp. 89-111). In: WALTHERG, R., BURGA, C.A. & EDWARDS, P.J. [eds.] '*Fingerprints' of climate change. Adapted behaviour and shifting species ranges*. Kluwer Academic/Plenum Publishers.

PARR, A. J. (2010) Monitoring of Odonata in Britain and possible insights into climate change (pp. 127-140). In: OTT. J. [ed.] *Monitoring Climatic Change with Dragonflies.* Pensoft Publishers, Sofia, Bulgaria. 286 pp.

PEDLEY, M., HUGHES CLARKE, M. & GALEA, P. (2002) *Limestone Isles in a crystal Sea*. PEG Ltd, Malta. 109 pp.

RISERVATO, E., BOUDOT, J-P., FERREIRA, S., JOVIĆ, M., KALKMAN, V.J,, SCHNEIDER, W., SAMRAOUI, B. & CUTTELOD, A. (2009). *The status and distribution of dragonflies of the Mediterranean basin*. International Union for Conservation of Nature. Gland, Switzerland and Malaga, Spain: IUCN. vii + 33 pp.

SEBASTIAN, A., SEIN, M. M., THU, M. M. & CORBET, P. S. (1990) Suppression of *Aedes aegypti* (Diptera: Culicidae) using augmentative release of dragonfly larvae (Odonata: Libellulidae) with community participation in Yangon, Myanmar. *Bulletin of Entomological Research*, **80** (2): 223-232.

SCHEMBRI, P.J. & SULTANA, J. [ed.] (1989) *Red data book for the Maltese Islands*. Department of Information.142 pp.

SCHEMBRI, P.J. (1991) *Ekoloġija tal-Gzejjer Maltin: Ħarsa Ġenerali* (pp. 5-37) In: CORTIS, T. [ed.] Oqsma tal-Kultura Maltija. Ministeru tal-Edukazjoni u tal-Inter. 296 pp.

SULTANA, J. [ed.] (1995) *Fawna u Flora ta' Malta.* Floriana, Dipartiment għall- Ħarsien tal-Ambjent, 434 pp.

SCIBERRAS, A. & SCHEMBRI, P.J. (2006) Occurrence of the alien Bedriagaís frog *(Rana bedriagae)* Camerano, 1882 in the Maltese Islands, and implications for conservation. *Herpetological Bulletin*, **95**: 2-5.

SCIBERRAS, A. & SAMMUT, M. (2008) On the occurrence of *Calopteryx virgo meridionalis* (Selys, 1873) (Odonata: Calopterygidae) in the Maltese Islands. *The Central Mediterranean Naturalist*, **4**(4): 339-342.

SCIBERRAS, A., SCIBERRAS, J. & KUNZ, B. (2010) *Orthethrum nitidinerve* new to the Maltese Islands (Odonata: Libellulidae). *Libellula*, **29**(1/2): 55-60.

SHIMURA, S. (2003) *Egg parasitoids wasp of Anax parthenope* Julius [available on-line http://tombon.com/ENGPAAnax.htm. Accessed 16.iii.2006].

SILSBY, J. (2001) *Dragonflies of the World.* Washington, DC: Smithsonian Institution Press. 224 pp.

TERMAAT, T., KALKMAN, V.J. & BOUWMAN J. H. (2010) Changes in the range of dragonflies in the Netherlands and the possible role of temperature change (pp. 155-174). In: OTT, J. [ed.] *Monitoring Climatic Change with Dragonflies.* Pensoft Publishers, Sofia, Bulgaria. 286 pp.

TILLYARD, R.J. (1917). *The Biology of Dragonflies.* Cambridge University Press. 396 pp.

UTZERI, C. (1986) Oviposition of *Sympetrum* into sea water and other records of unusual dragonfly behaviour (Zygoptera: Calopterygidae: Anisoptera: Aeshnidae; Libellulidae). *Notul. Odonatol*., **2** (7): 113-4.

VALLETTA A. (1949) A preliminary list of the Odonata of the Maltese Islands. *The Entomologist*, **82**: 85-87.

VALLETTA, A. (1957) Second contribution to the Odonata of the Maltese Islands. *The Entomologist*, **90** (1135): 306-307.

WILDERMUTH H. (2012) Die verbreitung der an Libellen (Odonata) parasitierenden Gnitze *Forcipomyia paludis* (Macfie, 1936) in der Schweitz (Diptera: Ceratopogonidae). *Entomohelvetica*, **5**: 71-83.

WILIGALLA, C. & FARTMANN, T. (2012) Patterns in the diversity of dragonflies (Odonata) in cities across Central Europe. *European Journal of Entomology*, **109**: 235-245.

WOOTON, R.J. & NEWMAN, D.J.S. (2010) Evolution, diversification and mechanics of dragonfly wings (pp. 261-275). In: CÓRDOBA-AGUILAR, A. [ed.] *Model organisms for ecological and evolutionary research*. Oxford University Press. 290 pp.

Received: April 30, 2013
Accepted: October 10, 2013

ADDENDUM

A paper by Sciberras & Sammut (2013) was published at a later stage of production of this work. Some issues from in this paper are discussed in the following addendum.

Species record updates

Aeshna mixta. The authors record more sightings of *A. mixta* in the Northern part of Malta, Gozo and Comino. These records indicate that the species might become a more regular visitor to the Maltese Islands. The distribution map shown has been drawn to include all records to date.

Examination of material from the private collection of the late Mr A. Valletta has revealed another *A. mixta* specimen dating from 1948 and misidentified as *Anax imperator*. The mentioned sighting by Degabriele in 2011 is inaccurate and probably refers to the sighting by Ruf *et al.* (2011).

Orthetrum brunneum. The authors update the most recent records for this species to 2010 in the same location mentioned for this species in this work though no specimens seem to have been taken. Exuviae are also suspected to be found and are currently under study (Sciberras, A. *pers. comm.*).

Orthetrum nitidinerve. Sciberras & Sammut (2013) also update the most recent records for this species to 2011 from Wied Riħana.

Selysiothemis nigra. According to Sciberras & Sammut (2013), *S. nigra* is also recorded from Comino and from the South of Malta.

Changes in status records of species

Sciberras & Sammut (2013) claim that *Orthetrum cancellatum*, *O. coerulescens anceps* and *Sympetrum striolatum* are being replaced by *Orthetrum trinacria*. However the decline of these species has occurred before the first local records of *O. trinacria*, with that of *S. striolatum* first recorded in the early 1990's (Degabriele, 1992) while that of *O. cancellatum* noticed in the early 2000's. It is therefore possible that the decline of these species could be due to reasons other than the presence of *O. trinacria*. The issue of the decline of *S. fonscolombii* was discussed on pg. 82. In the case of *Othretrum coerulescens anceps,* fieldwork observations by the author in 2012-13 showed that: (i) *Orthetrum coerulescens anceps* numbers were not in decline although the species tends to only be found in specific habitats and (ii) *O. coerulescens anceps* and *O. trinacria* do not frequent the same type of habitats (also mentioned by Balzan, 2012). As discussed on pp. 70 and 74, while *O. trinacria* is present in areas with large open standing water bodies, *O. coerulescens anceps* prefers small standing or moving water bodies which are sheltered by trees.

REFERENCE

Sciberras, A. & Sammut, M. (2013) On the occurrence of the Copper Emerald, *Calopteryx haemorrhoidalis* (Van der Linden, 1825), records of rare species, changing population trends of some hitherto common species and recent colonizers in the Maltese Islands. *Journal of the British Dragonfly Society*, **28**: 1-9.