Trithemis annulata

Introduction to Dragonflies

ORDER ODONATA

Dragonfly is a colloquial expression for the order Odonata. It comes from Greek word 'odontos', which means 'teeth'. This is because one of their features are jaws with teeth inside. The order Odonata can be split in two groups. The first group are called Damselflies or the suborder Zygoptera ('zigo' means 'the same' in Greek, and 'pteron' is 'wing'), and the second group are proper dragonflies or the suborder Anisoptera (meaning 'different wings' from the Greek words 'aniso' - 'different' and 'pteron' - 'wing'). Therefore, one of the main differences between damselflies and dragonflies is the shape of their wing. In the case of damselflies, their forewings are very similar to the hindwings, while in the case of dragonflies these are not the same.

The rest of differences are to be shown further on.

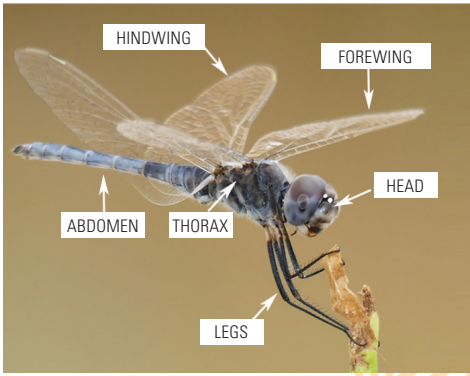
ORIGIN OF DRAGONFLIES

Dragonflies are considered to be one of the oldest insects on earth. Their 320-million-year old fossils were found from the Carboniferous period. Those first dragonflies that we know of were very big insects. Some of them were the largest insects that have ever existed, with a wingspan bigger than 70 cm. In other words, this is a wingspan of a sparrowhawk.

The dragonflies we can see today are rather recent, as they come from the middle of the Permian period (between 300 and 250 million years ago). Then damselflies (Zygoptera) appeared, while proper dragonflies (Anisoptera) came later on, more or less in Jurassic, 200 million years ago.

MORPHOLOGY

As all insects, the Odonata's body is divided in three parts: head, thorax and abdomen. Moreover, they have four wings with membranes – two forewings or front wings and two hindwings or rear wings, which allow them to move while flying; and six legs – two fore, two middle and two hind legs, which they need to stand and rest and capture their prey.



Simplified Morphology of a Dragonfly: *Selysiothemis nigra*

Head

Eyes stand out on the head. Dragonflies that belong to the order Odonata have one of the most developed and complex visual systems in the animal world.

Their eyes consist of thousand facets (parts that make the eye), which allows them to capture a great amount of light and provides them with an exceptional vision. Their keen-sightedness, together with the position of their eyes and head movements give them near-360-degree vision.

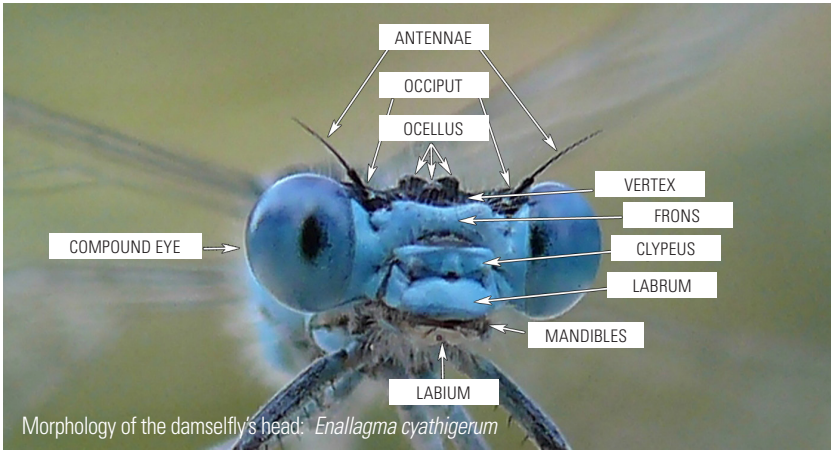
Damselflies and dragonflies have different heads and eyes, so the comparison of these parts of their bodies is the easiest way to make difference between these two groups. Damselfly's eyes are smaller than in the case of dragonflies. They are placed on both sides of their head with a large area between them, called vertex, which makes them look like a hammer.

There are three simple eyes or eyespots (ocellus) on the vertex, two superposition smaller eyes and a bigger one beneath.

The rear area of the vertex which connects the eyes is called occiput. It has spots behind the eyes, which colour and size differ among species. The antennae are very small and bold at the bottom. The frons is below them. There are some sensory hairs under them and on the vertex.

A semicircular area, called clypeus, is placed under the frons. It is divided in two parts: postclypeus (the upper part) and anteclypeus (its lower section).

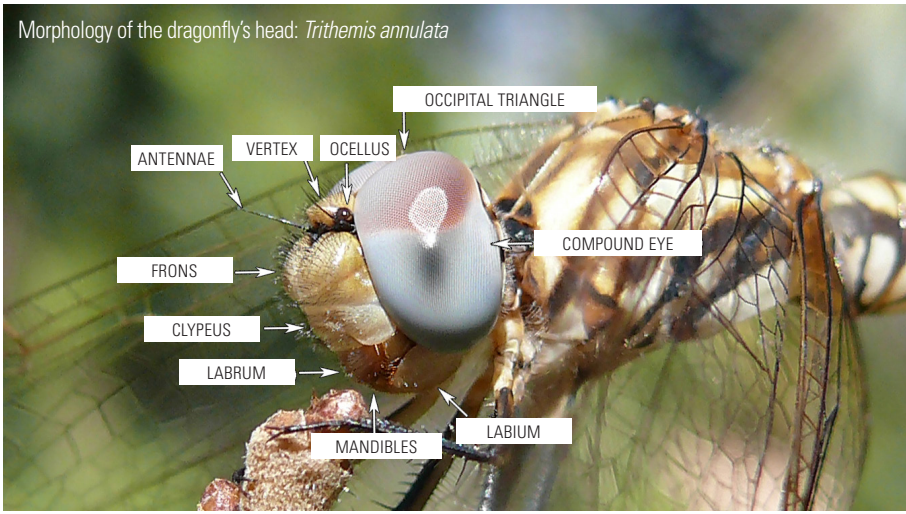
The clypeus and the labrum, which is placed beneath, make a kind of protection shield that protects the jaws, made of two upper mandibles with teeth, two pairs of lower maxillae, and the labium, a lower lip that protects the inside of the mouth.



Morphology of the damselfly's head: *Enallagma cyathigerum*

Dragonfly's head is much bigger and round. The eyes cover a large part of the head and meet at some point of the head, normally on the upper part, except in the case of Gomphidae.

The occiput is reduced to a small occipital triangle behind the eyes, the same as the vertex, so there is little space left for the antennae and the ocellus. It has wide frons and the same organs as damselflies: clypeus, labrum, mandibles and labium. In the case of dragonflies, sensory hairs can be all over the head, except on the eyes.



Thorax

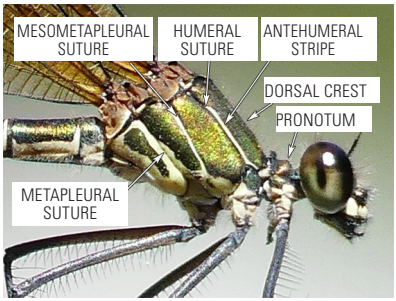
The thorax is split in two segments – prothorax and synthorax. The prothorax is very small comparing to the synthorax, and has bears the first pair of legs – forelegs.

The upper part of the prothorax is called pronotum, and it is often used to make a difference among damselflies species, as in each of them, its shape and colour are different.

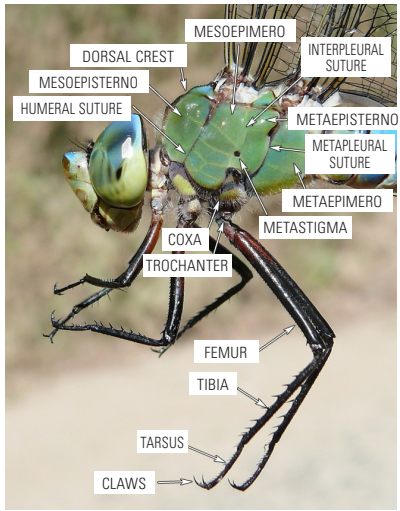
The synthorax is larger and robuster, as most of the important organs are placed there, as well as the wings and the muscles that move them. It consists of two sections, mesothorax and metathorax, which are fused together.

The mesothorax is where the wings, forelegs and middle legs are. The hindwings and the hindlegs are placed on the metathorax. Varied parallel and diagonal stripes stretch over the synthorax. Each of them has its names as well as the space between them. Moreover, there are 'metathoracic spiracles (metastigma)' on each side. These area actually holes for breathing.

In order to avoid the excessive use of this kind of terms and make the reading easier, we will refer to synthorax as thorax and we will use the above expressions only when necessary.



Morphology of the dragonfly's thorax. *Calopteryx haemorrhoidalis.*



Morfología del tórax y patas de una libélula *Anax imperator.*

Legs

Legs are not made for walking, but for handling and trapping prey. Forelegs are shorter than hindlegs. Morpology ot the thorax and legs of a dragonfly Anax imperator.

They are divided in different parts: coxa, trochanter, femur, tibia, tarsus and a pair of claws. Femurs and tibias can have sensory hairs on them, the same as the head and thorax. These help handle food.

Wings

Odonates have long and round ends of the wings, which are covered in membranes and many veins that hold together all its parts. Each vein or the group of veins have their name, although the most prominent are Costa (front margin of each wing), Subcosta (the one below the costa), Nodus (the vein that goes across the costa), radial veins (R1, R2, and so on), interradial veins, and secondary veins. They are normally black but some species can have yellow, orange or reddish veins. The space between each vein is called cell.

Most of species have transparent cells, although sometimes they can be orange, red or black. One of the cells, known as pterostigma, stands out.

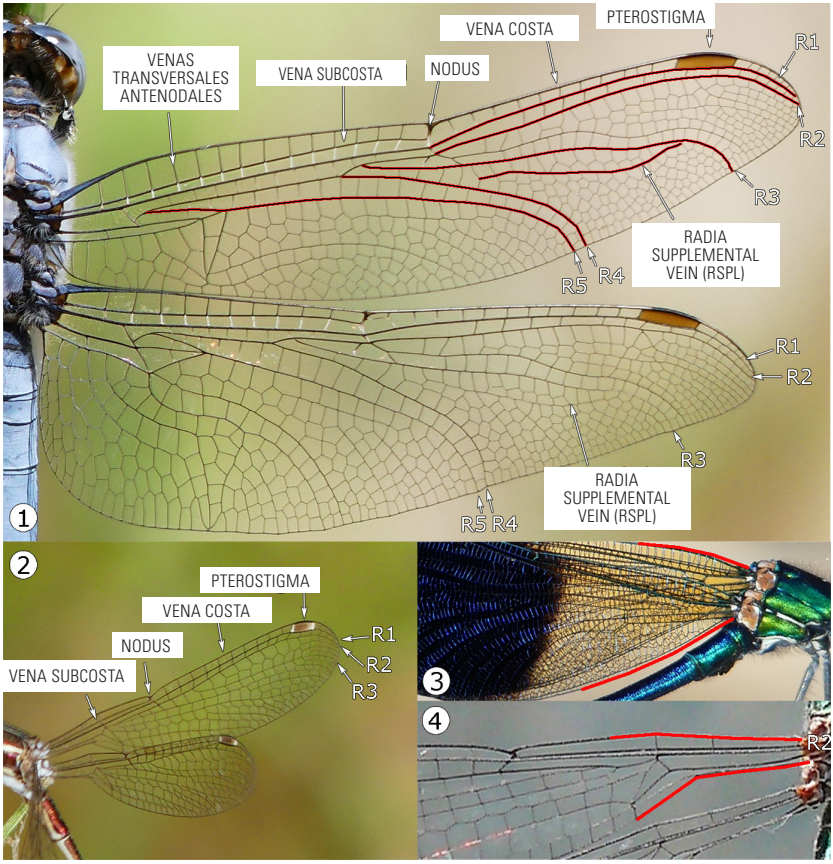
The pterostigma is placed close to the edge of each wing, or the apical angles, is dark and coloured (in some species, it is two-coloured), and its shape, size and colour can often help make difference between species.

All dragonflies and damselflies in Málaga, male or female have a pterostigma, except the Calopterygidae family. In their case male dragonflies do not have them and the females do, but it is hardly developed, though clearly seen, and called pseudopterostigma.

Dragonflies and damselflies have different wings. As said above, damselflies have four rather similar wings, but in dragonflies hindwings are wider than forewings and their veins are different. The base of damselfly's wings have an enlarged and thin part, and it widens a bit further on, except in the case of the Calopterygidae family, whose wings widen from their beginning.

Damselflies flutter is somehow timid. Their flight pattern is sometimes bouncy, while dragonflies fly straight and powerful. When at rest, damselflies hold their wings up or back completely closed or at an angle from the body.

Dragonflies cannot close their wings like this so they usually keep them open while resting. They make a shape of a cross, holding them down or upwards, and covering the thorax.



1-2. Simplified dragonfly's wing structure of the Orthetrum brunneum and the wing structure of a Lestes virens damselfly . 3-4. Difference between the base of the damselfly's wings in the family Calopterygidae (Calopteryx xanthostoma) and the rest of the families (Chalcolestes viridis).

Abdomen

Parts of the digestive and respiratory system, as well as genitalia are placed in the abdomen. It is prolonged and normally cylindrical, although it can be flat in some species. It is divided into ten segments and anal appendages, as well as other reproductive organs. The segments are numbered from 1 to 10. The first one (S1) connects the abdomen to the thorax and is normally reduced.

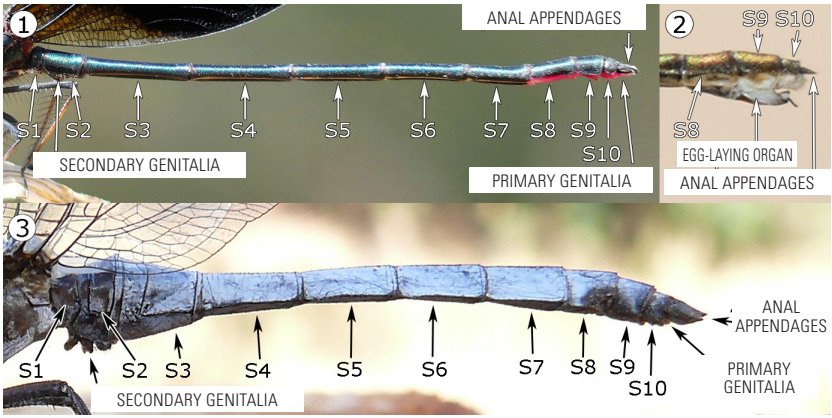
The rest of the segments can are different in size. The last ones, S8, S9 and S10, are usually shorter. The thickness of the abdomen is also changeable, though they are thinner in damselflies than in dragonflies.

Moreover, the segments can have different thickness, as the first ones are usually thicker than those at the end. In the case of some species, the males can have S2 and S3 much thicker than the rest of segments. This is also possible in the case of segments 7, 8 and 9 in some other species. Each of the segments have a hole for breathing. Reproductive organs are placed in last segments in both, male or female dragonflies.

Anal appendages are more developed in the case of the males than in the females. They consist of two superior or upper appendages called *cerci* (singular: cercus) and one lower or inferior appendage in dragonflies and two of each in damselflies.

Moreover, the males have a kind of deposit, called secondary genitalia, which is placed under S2 and holds sperm. The females do not have this secondary genitalia, but they have the cerci on S10 and a well-developed genital structure on segments 8 an 9, which is why they are thicker.

The ovipositor cannot be seen in the species which lay eggs directly into the water while flying as it is underside, but it is external in the case of the species that lay eggs inside the plants.



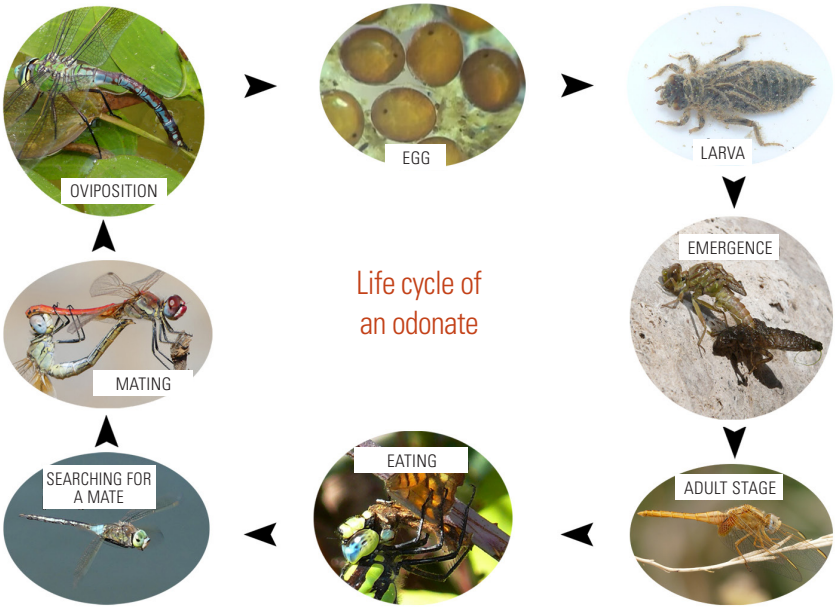
1. Different parts and abdominal organs of a male damselfly, Calopteryx haemorroidalis. 2. Anal area of a female damselfly, C.haemorrhoidalis. 3. Different parts and abdominal organs of a male dragonfly, Orthetrumco erulescens.

1. Anal area of a female dragonfly, Aeshnamixta 2. First thick segments in a male dragonfly, Orthetrum trinacria. 3. Last thick segments in dragonflies, Cordulegaster boltonii. 4. Anal appendages of a male damselfly, Chalcolestes viridis. 5. Anal appendages of a male dragonfly, Onychogomphus forcipatus.

BIOLOGY OF DRAGONFLIES

The biology of dragonflies and damselflies have been some of the most interesting questions regrading them. The fact that two first stages of their life cycle, larva and adult, develop in two totally different environments, such as water and air, have always fascinated people who are keen on studying them.

The stages in the life cycle of odonates are the egg, the larva and the adult stage or imago. All these stages are different and require special attention. These creatures are complex and curious, and show extraordinary behaviour and adapting skills.



Mating

Mating is one of the most interesting moment in the life cycle of odonates, as their bodies make the shape of a heart during it. There are three different stages which happen before, during and after the mating. The whole process starts with a series of events which are rather important for the successful reproduction of the individual.

The male recognizes the female through several features, such as its colour, size, transparency of its wings and its movements during the flight. However, a female Ischnura graellsii and Anax imperator sometimes simulate the colour of males (andromorphism) in order to not to be detected by them, especially during oviposition.

Calopteryx males are rather similar among them, and their varied species can live together at the same place. Because of this, the males lift their abdomen and show the lower part of its last segments which is differently coloured in each species so to be recognized by their species' females. Once they have been recognized, the male tries to find out if the female consents mating.

In the case of dragonflies, females which are not receptive usually reject males by raising the last abdominal segments and slightly opening their wings. Anyhow, the female is the one that chooses the male partner.

In dragonflies which are less territorial as well as most damselflies, the size of males is decisive factor in the choice made by females.

In the case of dragonflies, which are much more territorial, those males that live longer are more successful in reproduction. Before the mating starts, the male must pass the sperm from the main genitalia on the last segments to the secondary genitalia on the lower part of S2. They do that by folding the abdomen until the main and the secondary genitalia join together. Once the sperm gets to the right place, the mating starts. The male flies close to the receptive female.

1. Calopteryx haemorrhoidalis male is showing the lower part of the last abdominal segments to females. Photo: Teodoro Martínez.
2. Visual signs of rejecting mating made by Calopteryx virgo female.

The male holds the female's thorax with its legs and folds its abdomen in order to hold the female's prothorax (damselflies) or the back of the female's head (dragonflies) by its anal appendages (cerci and the lower ones).

This way the female can lean its abdomen in order to join her genitalia with the male's secondary genitalia, when the sperm displacement happens and the copulation wheel in the shape of a heart is made.

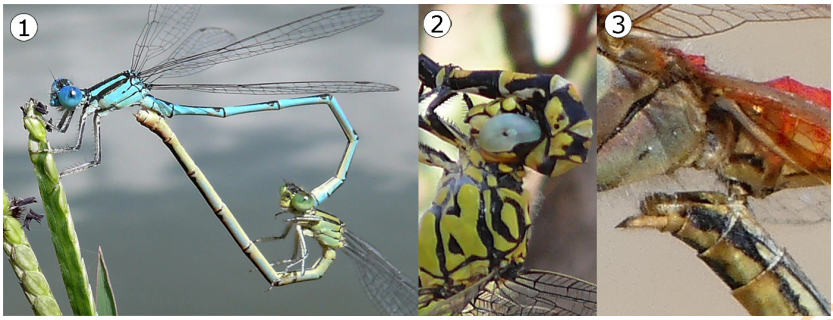
Before mating, they can fly together for some seconds or even hours, which is called premating or 'tandem flight'. They fly in tandem early in the morning and sometimes before the female's consent, as there is to wait for a while before the mating starts.

Damselfies always make the copulation wheel while at rest, while some dragonflies are more likely to do it during flight. Mating normally takes short time, actually, less than a minute. However, it has been evidenced that some damselfly species that can mate for more than six hours.

One female can mate with various males, as it can storage the sperm. It is also possible that the male eliminates the sperm of other males so that he becomes the one that performs the insemination.

Crocothemis erythraea male passes the sperm from the primary to the secondary genitalia.

There are several ways to do so: by scooping out other male's sperm with his spoon-shaped penis and the appendages known as claspers in some species; by displacing the other male's sperm to the parts which the female uses less; by stimulating the areas of the female's genitalia so that the female would throw out the sperm from the previous copulation; and depositing sperm several times so the probability that the female gets inseminated by this one becomes higher.



1. Erytromma lindenii mating process. 2. Hooking-up during the mating process of Onychogomphus forcipatus. 3. Genitalia contact in Sympetrum fonscolombii.

Odonates are not likely to go through hybridization as their genitalia varies in different species, so they are incompatible in the majority of cases. However, some hybridization cases were recorded between some Iberian species, such as Ischnura graellsii and I. elegans.

No hybrids have been seen in species from Málaga, though two different species were observed in tandem. On two occasions, these were Orthetrum trinacria males and O. cancellatum females; O. chrysostigma male and Sympetrum fonscolombii female; Crocothemis erythraea male and Trithemis annulata female.

Tandem between an Orthetrum trinacria male and an O. cancellatum female.

In none of the cases, copulation or oviposition have been seen. After mating, the tandem can separate or carry on. This depends on the oviposition process in each species.

Oviposition

In some species, females lay eggs on their own, while in others males are joined to them. There are also species which are not joined during this process but the male goes around the female and defends her from other males and protects the place with eggs from other females which want to oviposit there.

During oviposition, some species of damselflies behave in a rather curious way. Chalcolestes viridis and Platycnemis latipes, among others, lay eggs while they are still connected, and dozens of pairs can be seen at the same place.

Some females plunge half or all their body into water and lay eggs over the water plants. These are species in the genus Calopteryx, such as Pyrrhosomma nymphula and Erythromma viridulum, which lay eggs while connected to the male or without him. Moreover the male can submerge as well.

There are three different types oviposition depending on the surface it is performed on:

Endophytic oviposition is performed by the female that lays eggs inside aquatic plants tissue, floating pieces of plants or shore plants including bushes and trees. This is a rather primitive egg-laying system which is followed by all damselflies and Aeshnidae family of dragonflies. Females use a bladelike ovipositor or egg-laying organ to saw plants and place the eggs inside their tissue. The eggs are normally placed in aquatic plants or pieces of floating plants, so they are splashed by water at all times. However, there are some Lestidae, which insert eggs under the bark of the willow branches that are close or above water.

• Epiphytic oviposition happens when the eggs are laid on the aquatic plants and not inside them. The eggs are covered by a gelatinous film which sticks them on the plant.

• Exophytic oviposition means laying eggs on the water or some nearby surface by the female or in tandem. Eggs are splashed into the water from a small hight during the flight or placed over the water surface, as the female continuously dips the tip of the abdomen into water while dropping the eggs.

1. Anax imperator is inserting the eggs into the floating plants alone. 2. Sympetrum fonscolombii dragonflies in tandem while laying eggs onto the water. 3-4. Chalcolestes viridis in tandem while inserting the eggs in a blackberry stem of a out of water. 5. Erythromma viridulums in tandem, while the female is laying eggs with the half of her body immersed in the water. 6. Two pairs of Platycnemis latipes that are laying eggs together in the stems of rush.

Egg

Egg-laying strategy defines the appearance of an egg. Endophytic eggs are elongated, while epiphytic and exophytic eggs are round. Their colour ranges from green to brown or orange shades.

The size depends on the species, whereas the smallest belong to damselflies (approximately 480 by 230 µm), and the biggest ones are some species of dragonflies (700 by 600 µm). The development of the embryo can last some eight weeks. Generally speaking, it is longer in the case if dragonflies.

Some eggs take longer to hatch as they start to develop the embryo after they have been placed. Some can even take 150 days to start, and go through a long state of suspended development called 'diapause'. This strategy is the most common in the case of species that lay eggs in autumn, and their larvae emerge at the end of winter and in spring when the water temperature is the best for their development.

There is a kind optional (facultative) diapause when odonates can actually lay eggs without preforming diapause. They hatch very fast in they are laid before summer, or go through diapause.

Larva

After the hatching, the egg becomes the prolarva. This name is due to its small size and amorphous shape, which hardly allows its different parts of the body to be distinguished. It immediately looks for some shelter in water, considering that this is the most delicate period in its life. In the case of Lestes damselflies, which lay eggs on brunches and bushes outside the water, the larva jumps in a rush in order to reach it.

Odonata larvae breathe oxygen which is dissolved in water. Breathing organs are different between damselflies and dragonflies. Dragonflies have their respiratory system on the outside of their body where they have three anal lamellae with a great number of tracheae they use to get the oxygen.

Dragonfly`s respiratory system is also placed at the end of abdomen but, unlikely damselflies, it is inside of the body. It sucks the water and throws it out once the oxygen is taken by tracheal compression movements which they also use to move forwards fast when necessary.

Some species can live in water with a low concentration of oxygen,

Damselflly's larva, the genus Lestes. Three anal lamellae for breathing stand out.

and even get out of the water in humid areas for several days or weeks.

Odonata larva is a predator. Its diet depends on the stage of its life cycle. Therefore, one species can feed differently during its life. It can eat almost any aquatic organism that is smaller or the same size as the larva, from protozoans and young microinvertebrates to small fish and amphibian larvae.

Odoata larvae can even eat other odonates (including their own species' larvae). In the case of big dragonflies, they can even eat female damselflies which lay eggs under water.

There are two techniques larvae applies when hunting. The most common one is to hide under stones, plants, or half-buried in the bottom of the water and wait for the prey to come. Another less common technique is to be 'on patrol' and attack everything that comes on their way.

Once larvae choose their prey they take out their 'mask', something common in damselflies and dragonflies. This is a retractile appendage made by transforming the lower lip into long palps with moveable hooks which allow it to hold the prey. This is how larva can hunt from some distance in a similar way to chameleons that catch the prey with their tongue.

Larvae grow and change their skin all the time. They do it between ten and twenty times depending on the species, as the skin can stretch but it cannot grow. The time a larva takes to grow depends on the food it can approach to and the water temperature. In some cases, these two things are related.

In the south of Europe, the higher the temperature is, the more prey exist, and, therefore, larvae develop faster. However, in northern areas, where the water temperature is lower, food supply is poorer and they grow more slowly. Some species, actually take months or years to complete their larval stage.

In this situation, larvae start the winter diapause and they wake up when the conditions are appropriate. On the other hand, some specie finish this stage rather soon and can have several generations a year thanks to the good weather conditions, above all in southern areas.

Larva (left) and the 'mask' (right) of Anax Imperator. *Photo: Francisco de Erit Vázquez Toro.*

Metamorphosis

This is a previous step to emergence. During the last larval stage, there are series of changes in the larva's appearance, physiology and behaviour. One or two weeks before they emerge, larvae stop eating due to a hormonal change. Juvenile hormone, which inhibits metamorphosis, is produced less so the transformation process is possible.

Thanks to this, the adult insect starts forming inside the cuticle. Its eyes start growing and getting darker, the lower lip draws in, and the traces of the wing bags start inflating. At the same time, the nymph goes away from deeper water and closer to the shore. It even breaths out of water in order to slowly start getting used to living on the surface.

Emergence

Dragonfly or damselfly larvae carefully choose the place where to emerge. These places need to have a series of features, like a surface where to grasp, certain amount of light and weather conditions. Different species use different surface for emerging.

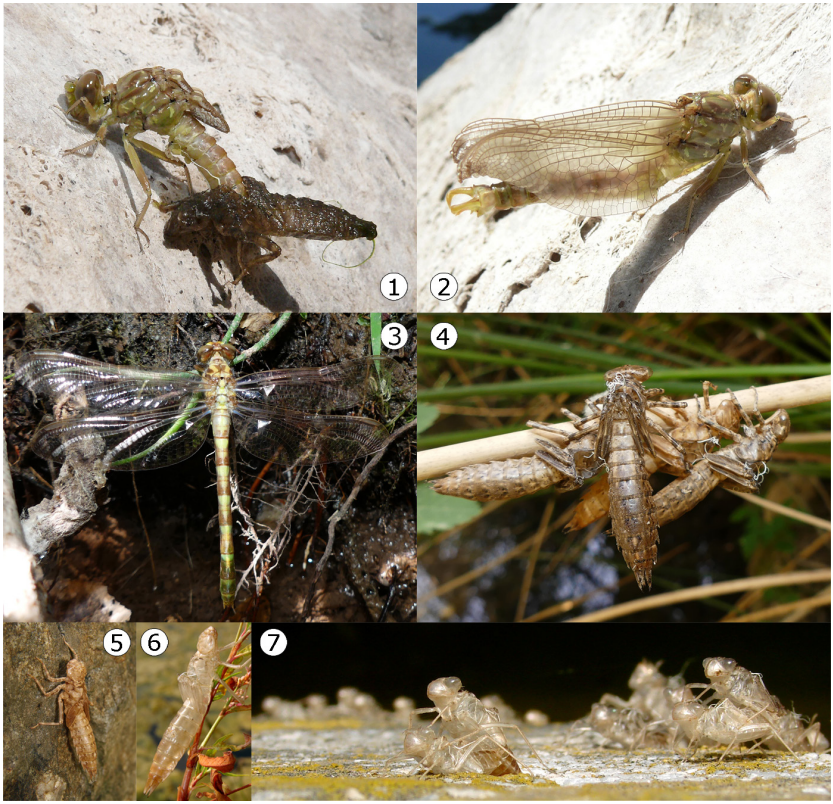
Damselflies and some dragonflies prefer vertical surface, such as reeds or reedbed and bulrush, as well as other woody plants on shore or in water. Other dragonflies emerge on horizontal surface, above all stones or stalks. Generally speaking, larvae can climb up to the places where they emerge from 5 to 20 cm high, but some can even climb rocky walls and trees as high as five metres, and go far away from the shore.

Having chosen a suitable place and grasped the surface with their legs, larvae start emerging. They tear skin on the outside along dorsal area, and first emerge their head and thorax. After a short break, their abdomen gets out as well.

This is the most critical moment in the life of damselflies and dragonflies. They cannot go back to the water as they are no longer nymphs, but they can neither fly because their body is still weak and their wings shrunk and wrinkled.

The emergence process starts when larvae abandon water and ends when imagos are able to fly, which all takes between one and three hours.

When they emerge, odonates leave behind their last larval moult, called 'exuvia'. This one can remain at same place for days or weeks, and it is the best way to confirm the reproduction of a species, which can be identified thanks to the morphology of moults if one knows what is necessary. It is not rare that exuvia becomes shelter for some arthropods, especially spiders, so there is to be careful when handling it. Plenty of exuvia can be seen on the wall or plants on the shore at the places with very few surfaces that can be used for emergence, such as lakes or river banks with hardly any plants.



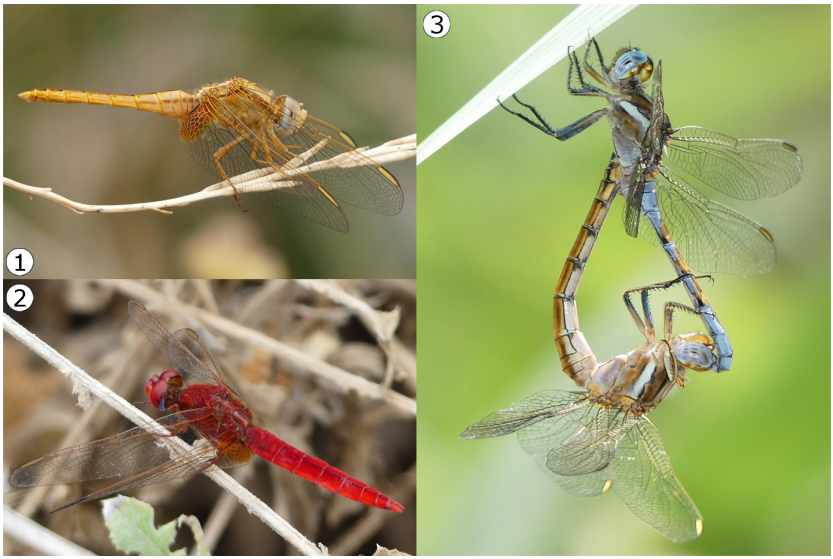
1-2. Emergence of Onychogom phusuncatus macho. 3. Recently emerged Onychogom phusuncatusfemale. 4-5. Boyeria irene's exuvia. 6. Anax imperator's exuvia. 7. A build-up of Libellulidae spp. 'sexuvias. Photos: Francisco de Erit Vázquez Toro (5-7).

Adult

Ones it emerges, the imago with open and strong wings starts looking for the ways to reproduce and continue with its species, which is the final aim of the adult stage. Before that it needs to become sexually mature.

The young Odonata has nothing to do with the mature Odonata's colouring. Generally speaking, their colouring is dull, such as greyish-brown and ochre, in order not to be unnoticed.

Normally, their colouring and markings become definitive only when the Odonata are sexually mature. However, there are some exceptions, like in the case of Orthetrum chrysostigma, which can mate before obtaining colours of its adult stage. Damselflies, which fly in a less powerful way and, generally speaking, live shorter than dragonflies, reach their adult stage faster than the latter ones, and keep close to the water and river banks, hiding between plants until they start mating.



Different colouring in an immature male (1) and an adult male (2) Crocothe miserythraea. 3. Mating of Orthetrumchry sostigma. It can be seen that the adult dragonfly that has not reached its final colouring yet, and has some yellowish stretches on the abdomen.

Sympecma fusca is an exception as it emerges in summer and gets far away from water, sometimes even several kilometres away, in order to spend autumn and winter growing so it can mate in spring.

Dragonflies usually grow longer than damselflies and can move further. Some do not go far away from water, and others go far away, and migrate as far as hundreds of kilometres away, as the species Anax ephippiger, which reproduces in the north of Africa and then moves north, stops in Scandinavia and Iceland several generations later, after having reached adult stage, in order to mate.

Other species like Aeshna mixta emerge in spring and spread to hide in big forest and mountainous areas. In autumn, when they become

Aeshna mixta female: while it is immature and hidden in a forest, far from water (up) and in the adult stage in the water while laying eggs (down).

sexually mature, they go back to their reproduction sites in order to complete the cycle.

Dragonflies and damselflies are voracious predators, both in their larval and their adult stage. From their emergence to the moment they become adults, their main aim is to feed themselves.

When they reach their full sexual maturity, their interest starts focusing on actions related to mating: choice and defence of the territory, courtship, and copulation. Some species males help females lay eggs or they protect them.

They feed on all kinds of insects, which they chew with their strong jaws. Their most common prey are insects from the order Diptera (flies and mosquitoes), the Hymenoptera (wasps and bees) or the Lepidoptera (butterflies).

Damselflies eat aphids (greenflies) and the Diptera they find in vegetation due to the fact they fly more slowly. However, dragonflies can catch wider range or preys, which includes other Odonata.

In the Province of Málaga, the most voracious predator of other Odonata that has been observed is Orthetrum trinacria. These damselflies are very good at hunting and eating, including small species, such aslschnura graellsii, and big ones likeCrocothemis erythraea. Nevertheless, Anax parhenope stands out because it can detect other aeshnids, like Aeshna mixta.

Orthetrumtrinacria while eating a butterfly Polyommatuscelina (1) and a dragonfly Crocothemiserythraea (2). Anax parthenope eating a Aeshna mixta (3).

Most of dragonflies and damselflies hunt while flying. Some can eat their prey while flying as well, while others rest and then start eating. They visually detect their prey. Their extraordinary vision allows them to see their food at a distance of twenty metres or more, like aeshnids do. Binocular vision is more developed in damselflies as they can see their prey better between plants.

The Odonata males are rather territorial, especially dragonflies. Once they find appropriate water habitat where the female can lay eggs, they defend it fiercely. Therefore, it is normal to see adults that belong to the same or different species compete between themselves at some places. They can chase one another, hurt or even cause one's death. Generally speaking, damselflies are not so territorial considering that we can many couples laying eggs close to each other, as it was previously said.

ENEMIES OF DRAGONFLIES AND DAMSELFLIES

Dragonflies and damselflies' larvae and adults are both rather skilled predators. However, they belong to the food chain and have a series of enemies that hunt them whenever possible. The Odonata larvae can be eaten by fish, birds (dipers, kingfishers or the white wagtail, for instance), and other larvae form their own order.

In order to protect themselves, they hide or camouflage themselves, although dragonfly's larvae can escape by expelling water through a hole on their anal zone that they use to breathe. When they become adults, they have a large rang of enemies, which can be predators or parasites. The first group mainly consists of birds. While the imago is emerging, chiffchaffs, dipperss and wrens can detect it, above all if it is a dragonfly.

When adult dragonflies or damselflies start flying their biggest predator is a bee-eater. This bird which is specialized in catching flying insects can eat a big number of odonates, above all dragonflies, some of which are larger like aeshnids and Cordulegaster boltonii.

Beside birds, dragonflies and damselflies are also preyed upon by other invertebrates. Spiders can above all

A bee-eater with a Cordulegaster boltonii in its beak. *Photo: José Manuel Gaona Ríos.*

trap damselflies, though some larger dragonflies, such as Oxygastra curtisii, have also been seen in their webs.

The Asilidae or the robber fly family and hornets also feed on dragonflies. The Odonata are also preyed on by other Odonata, as it was said in the previous chapter.

On the other hand, parasites do not kill the Odonata but they make their life shorter. These are normally the mites larvae (the red-coloured genus Arrenurus). They damage the thorax, abdomen and wings of the Odonata by exposing them to bacteria, which can reduce the body thickness and make the Odonata weaker and more vulnerable to the predators, or make females less fertile and even kill them.

Pyrrhosomma nymphula damselflly trapped by a Asilidae fly.

THREATS

As said in the previous section, the Odonata have many enemies, but only one of them, not mentioned above, represents a serious danger. It is a human. Even today, in the 21st century, there are still a lot of people who have no knowledge and have a lot of prejudice of dragonflies and damselflies.

The Odonata do not sting or bite, and they are neither poisonous. They are clearly not harmful for humans nor their activities, but quite the contrary. As it has been shown previously, they are rather useful as they eat other insect which can be harmful, such as flies and mosquitoes.

Considering that dragonflies and damselflies are connected to water ecosystems, preservation problems regarding these creatures depend on maintaining some minimum requirements for living conditions in suitable habitats.

Changes made on river beds and their destructions is a common threat for these animals in our province. In the 20th and 21st century, there were many changes on river flows made by building reservoirs and dams, and even drying some of the large rivers' sections, which lead to poorer biodiversity and fewer Odonata.

Today, we can still see how untreated toxic waste and sewage are being dumped into rivers and streams, which results in highly degraded water quality. Large infrastructures and buildings have helped destroying habitats at some sections of the rivers and streams, where canals or vaults were made at worst, so the life in water at these places became considerably poorer.

Destruction and/or changes made on river and stream flows are one of the biggest dangers for the dragonflies in the Province of Málaga.

On the other side, there is a great demand for water due to the high population density in the coastal area, which mostly depends on tourism and service supplies, such as golf courses, swimming pools, water parks, etc. There is also to add the latest increase in irrigated cropland.

The case of crops and golf courses are controversial. The water used for irrigation comes from aquifers, rivers and streams, where water is storage in reservoirs and taken to big ponds. When water is taken from the aquifers, their groundwater level becomes lower, which can result in a smaller amount of water on the surface of nearby rivers and streams, and sometimes it ends in dry springs and some rivers' sections.

Moreover, the changes made in natural water ecosystems by building dams or reservoirs, and the resulting fall in water flow, affect the natural balance of rivers and streams. These actions have negative impact on a large number of species, above all, those which reproduce at rivers. However, thanks to the water transfer to big ponds and artificial lakes, new habitats are made, and these can be inhabited by more common species.

There is also to mention how water is misused by residents and its waste in the water supply network, which also leads, though to a lesser extent, to a decrease in surface water in the case of the rivers, and in underground water as well.

The above factors which harm this kind of ecosystems also include climate change, which will probably cause more droughts, and, consequently, decreased river flow and less surfaces covered in water.

There is to underline that in spite of all these threats, there are still preserved river flows, which shelter real gems in the Province of Málaga, such as Critically Endangered (CR) Macromia splendens, and Endangered (EN) Oxygastra curtisii and Gomphus graslinii.

For the sake of preservation of dragonflies and damselflies in this province, it is necessary to provide an effective protection of water resources, something which depends on the willingness and need of society and people in charge to protect biodiversity in general, and the above insects in particular. It is also necessary to raise public awareness of environmental issues.

These creatures are to be presented to residents in a way they can start to appreciate their beauty and see how beneficial they are to ecosystems. Associations, such as 'El Bosque Animado' [Lively Forest] through the ROLA (Andalusian Dragonflies Watchers Network), have been studying the Odonata and offering workshops related to them in the resent years in order to raise knowledge and passion for these animals.

The Málaga County Council takes part in the promotion activities related to raising environmental awareness through this guide and varied workshops, such as the one celebrated in July 2017 in El Burgo. These actions are crucial for the preservation of dragonflies and damselflies in the Province of Málaga, considering that what is unknown cannot be loved and therefore protected.

Poster of the first workshop on dragonflies celebrated in the Province of Málaga by the asociatión 'El Bosque Animado' (on the left) and a moment form the workshop on raising environmental awareness organized by the Málaga County Council in El Burgo (on the right). *Photo: Jesús Ponce.*