GRASSHOPPERS

OF BRITAIN AND WESTERN EUROPE

A PHOTOGRAPHIC GUIDE

Éric Sardet, Christian Roesti
and Yoan Braud

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Title page image: Roesel's Bush-cricket (*Metrioptera roeselii*) adult female, clambering through grass, West Canvey Marshes RSPB Reserve, Canvey Island, Thames Estuary, Essex, England, September (Dave Pressland/FLPA).

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Matt Cole/FLPA

Common Field Grasshopper (*Chorthippus brunneus*) adult, close-up of head, Leicestershire, England, August.

Preface

Orthoptera are remarkable for the diversity of their shapes, colours, behaviours, habitats and lifestyles. Of the 27,000 species known worldwide, more than 1,000 occur in Europe (261 taxa are present in the area covered in this field guide). Many are familiar sights on country walks during the day as well as after dark. Grasshoppers can be detected by their jumps, while more discrete species may be found by careful listening, or by searching in specific habitats. With relatively low variation within species but high biological diversity and accessibility, the Orthoptera are a fascinating group of insects to study for all nature enthusiasts. However, their identification requires appropriate tools.

Identification is essential to proper observation: in order to describe what we see, and to compare with what has been documented by others, it is necessary to name specimens. Photographs cannot replace direct examination of characters, but building and maintaining a collection of insect specimens is a time consuming activity and, barring large-scale studies, it is often of little scientific interest.

This new guide focuses on the grasshoppers and crickets of Britain and Western Europe. It is an excellent tool to discover the diversity of Orthoptera: small, flexible and lightweight, it can easily fit into a pocket. With its many illustrations, it is intended not only for beginners, who will be able to gain fundamental knowledge about the morphology of insects, but also for experienced orthopterists. The identification keys combine drawings, photographs (with useful guidance on size) and distribution maps, for a quick assessment of possible options. It provides the best tools to make rapid progress in species identification. The book is accompanied by a CD that offers an overview of the acoustic diversity of Orthoptera. Finally, a brief summary of the biology of the Orthoptera is presented, as an introduction to finding and observing insects in situ.

In an era of climate change and major threats to biodiversity, improving our knowledge of the natural world can only help protect it. Everyone can contribute, each in their own way, to its conservation.

Laure Desutter-Grandcolas
Professor at the National Natural History Museum, Paris

Christian Roesti

Water-meadow Grasshopper (*Pseudochorthippus montanus*, female).

Introduction

The identification of Orthoptera can sometimes be a complex task. Until now, the resources available for identification were often outdated, incomplete, or insufficiently illustrated for the amateur. We hope that this guide with its accompanying CD of stridulations will fill this gap, and arouse greater interest in this fascinating group of insects.

The general section of this guide focuses on the anatomy, biology and ecology of the Orthoptera, as well as on methods used for their observation and study. We felt it to be important, particularly for beginner orthopterists, to include a description of specialised field equipment that can be used to take photographs, listen to or record sounds. The second part of this guide contains a richly illustrated key, incorporating the latest taxonomic changes. All 261 species in the region are illustrated with photos (of males and females), for the first time. We have also made a particular effort to update distribution maps, by reviewing various publications and by working with colleagues.

In the case of French Orthoptera, more than 1,100 new observations were collected, in addition to those used in the atlas published by the UEF (French Entomology Union) in 2009. Similar updates were undertaken for Belgium and Switzerland, in collaboration with national specialists, and for the UK following the Biological Records Centre's Grasshopper and Cricket (Orthoptera) and related species records from Britain and Ireland to 2007. We would like to thank all those who responded to our requests and shared their precious knowledge with us, thereby directly helping in the creation of the present book.

The authors,
Eric Sardet, Christian Roesti and Yoan Braud

Christian Roesti

Bormans' Alpine Saddle Bush-cricket (*Ephippiger terrestris bormansi*, male).

Classification

The Orthoptera (from the Greek *orthos*, straight, and *pteron*, wing) are insects with two hind wings that fold as in a fan, covered by the harder forewings: the elytra (also known as tegmina; singular: tegmen). They are characterised by their well-developed hind legs, adapted to jumping. 240 species and 21 subspecies of Orthoptera have been recorded in the area covered by this guide.

The order Orthoptera is divided into two suborders, the Ensifera (crickets and bush-crickets) and the Caelifera (grasshoppers and groundhoppers). This order belongs to the superorder Polyneoptera (formerly known as the Orthopteroids). Ensifera are for the most part omnivorous insects. All species of Caelifera and some Ensifera (*Phaneroptera falcata* and *Phaneroptera nana* for example) are phytophages, feeding mainly on plants, especially grasses.

It should be noted that, as with many groups, the classification of Orthoptera is constantly evolving. Revisions often concern the generic level (genus) but since the advent of genetic studies, revisions have also been taking place at higher taxonomic levels in families and even super-families. It can be difficult to navigate successive taxonomic changes, particularly as they sometimes end up being reversed!

Readers are advised to keep themselves regularly informed of changes to the classification of Orthoptera by using the **Orthoptera Species Files** (OSF) website, and the national list maintained by a French association, the ASCETE (Association for the Characterisation and Study of Entomocenoses).

In this guide, the ASCETE national list has been used as a reference, with the exception of the latest changes (Defaut, 2012) placing most species of *Chorthippus* into the genus *Gomphocerippus* (based on several genetic studies) and used in the classification of Chintauan-Marquier et al. (2015).

- **Division (or Phylum)** → Arthropodes (Arthropoda)
  - **Class** → Insects (Hexapoda / Insecta)
    - **Superorder** → Polyneoptera (Polyneoptera)
      - **Order** → Orthoptera (Orthoptera)
        - **Suborders** → Ensifera and Cælifera
          - **Superfamily**
            - **Family** → In the suborder Ensifera: Tettigoniidae (90 taxa), Rhaphidophoridae (10 taxa), Gryllidae (11 taxa), Mogoplistidae (4 taxa), Myrmecophilidae (4 taxa), Phalangopsidae (4 taxa), Trigonidiidae (5 taxa) and Gryllotalpidae (4 taxa).
              → In the suborder Caelifera : Tetrigidae (11 taxa), Tridactylidae (1 taxon), Pyrgomorphidae (1 taxon), Pamphagidae (2 taxa), Acrididae (114 taxa).
              - **Subfamily**
                - **Genus**
                  - **Species**
                    - **Subspecies**
                    - **Variety**
                    - **Form**

SYSTEMATICS OF THE ORTHOPTERA WITHIN THE ARTHROPODS

* The superorder **Polyneoptera** groups together: Phasmatoptera (stick insects), Dermaptera (earwigs), Dictyoptera (cockroaches, mantids), Embioptera (web spinners), Isoptera (termites), Notoptera (ice and rock crawlers), Orthoptera (grasshoppers and allies), Plecoptera (stoneflies) and Zoraptera (angel insects).

Anatomy

The bodies of Orthoptera are made of three parts: the **head**, the **thorax** and the **abdomen** (figure 1). Sexual dimorphism is present in most species of Orthoptera, with females being larger than males. This difference is more marked in the suborder Caelifera (figure 2).

THE HEAD

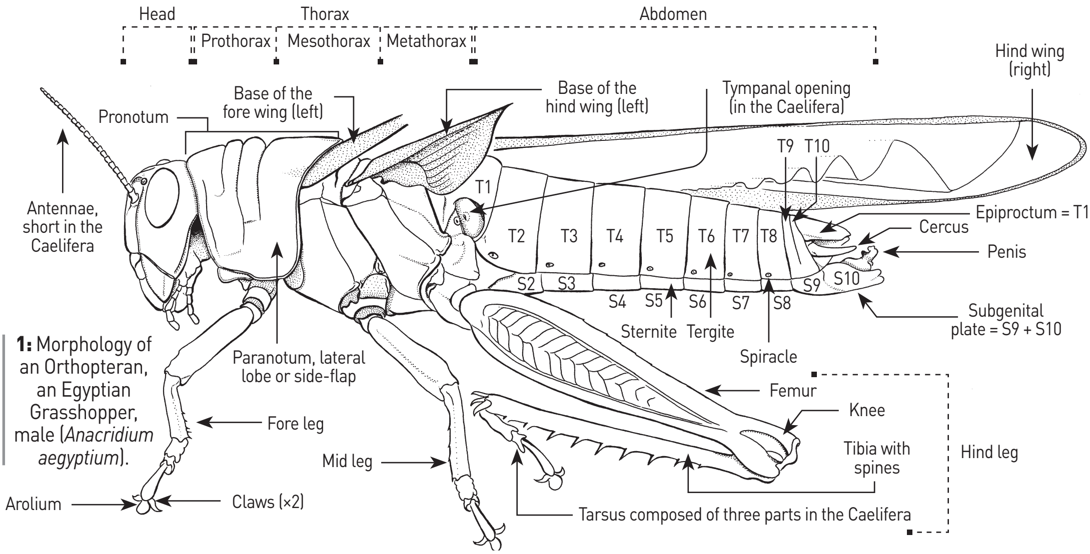
The head carries the mouthparts, the eyes and the antennae. The **mouthparts** consist principally of two strong **mandibles** covered by the **labrum** and framed by two pairs of **palps**, which are small, articulated, tactile and prehensile appendages (figure 3). During food ingestion, the labrum and the palps guide the food and hold it in place for mastication. The palps are also used to clean the antennae, the legs and in female crickets, the ovipositor. There are five eyes. These are of two types: **compound eyes** and **simple eyes (ocelli)**. The two compound eyes are located on either side of the head, and each comprises a number of independent units, the **ommatidia**. The simple eyes or ocelli are much smaller. The three ocelli are positioned in a triangle, two of them on the vertex, near the base of the antennae, and the third in the centre of the frons (figure 4). A few species have reduced ocelli and eyes; this is the case for cave-dwelling species for example. Diurnal Orthoptera have very good eyesight. The compound eyes are not only capable of distinguishing movement, form and changes in light level; they can also evaluate distances and relief. Some species of grasshopper can distinguish colours, such as yellow, green or blue. It appears that the ocelli have a role in light perception and in the detection of changes in light intensity. They guide directional orientation and movement, and are indispensable in maintaining general muscle tone. The **antennae** are far shorter in grasshoppers than in crickets and bush-crickets. This is an important criterion by which to separate the two suborders: the Ensifera (crickets and bush-crickets) have long, supple antennae, generally longer than the body and comprising more than thirty segments; the Caelifera (grasshoppers and groundhoppers) always have antennae that are shorter than the body (generally only about half its length), with less than thirty segments. In the Caelifera, the lateral foveolae (figure 5) are important morphological criteria for species identification. They consist of small depressions situated in front of the upper part of the compound eyes; they are triangular, rectangular or trapezoidal in shape. These are absent or hardly visible in some species.

THE THORAX

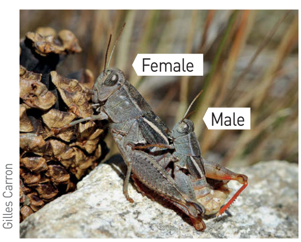
Located between the head and the abdomen, the thorax carries the organs of locomotion: the wings and the legs. It consists of three segments (from front to back): the prothorax, the mesothorax and the metathorax (figure 1).

Pronotum

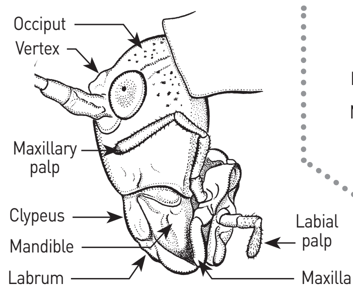
The dorsal part of the prothorax is called the **pronotum**. In the Bradyporinae subfamily, this has the shape of a horse saddle (figure 6). In the Groundhoppers it is elongated towards the back and covers the entire abdomen (figure 7); the pronotum can be a very important tool for species identification. It usually comprises two **lateral carinae** (side-keels) and a **median carina** (median keel, which are protruding lines, often underlined with white in Grasshoppers). The lateral carinae can be parallel, divergent only at the back or bent at the front and at the back (hourglass shape) (figure 8). In order to locate and describe the pattern of the carinae, two zones are distinguished: the **prozona** and the **metazona**, separated by a transverse groove, the **principal sulcus** (figure 8). The sides of the pronotum are called **side-flaps** (or paranotum, plural: paranota). The ventral part of the prothorax, carrying the first pair of legs, is called the **prosternum**; it is generally smooth but may be armed with spines or other protrusions (figure 9). This last criterion is important in distinguishing several subfamilies of Acrididae (they were once included in the Catantopidae due to this morphological feature).



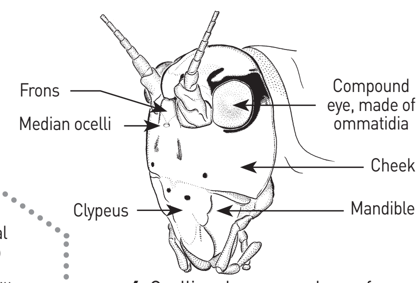
1: Morphology of an Orthopteran, an Egyptian Grasshopper, male (*Anacridium aegyptium*).



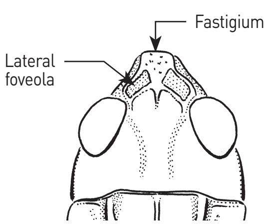
2: Sexual dimorphism – example of mating Pyrenean Pincer Grasshoppers (*Paracaloptenus bolivari*).



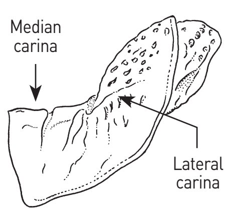
3: Detail of head and mouthparts.



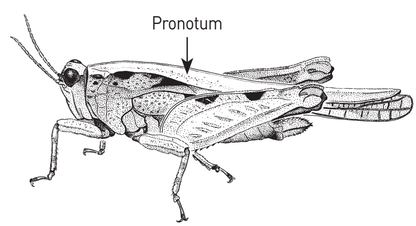
4: Ocelli and compound eye of Chopard's mountain Bush-cricket (*Antaxius chopardi*).



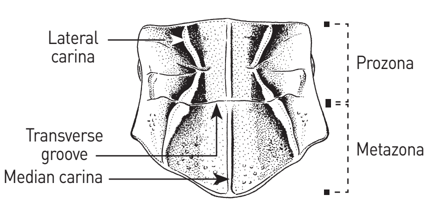
5: Distinctive shape of the lateral foveolae in certain species of Caelifera.



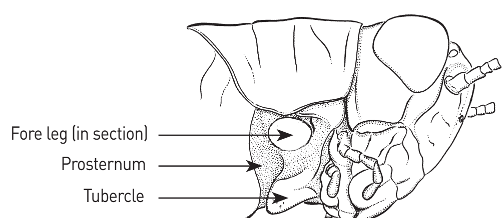
6: Profile view of a saddle-shaped pronotum, in certain species of Ephippigerinae.



7: In *Tetrix* spp. the pronotum is elongated; Cepero's Groundhopper (*Tetrix ceperoi*).



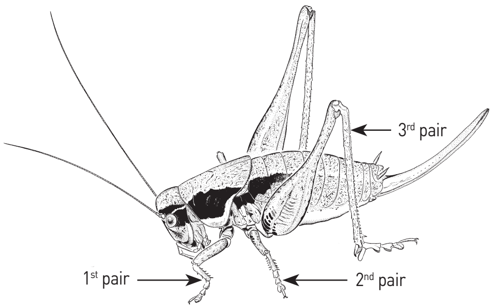
8: Dorsal view of a pronotum with divergent lateral carinae in the Festive Toothed Grasshopper (*Stenobothrus festivus*).



9: Presence in certain Caelifera of a hump or nodule on the prosternum (ventral view), Common Maquis Grasshopper *Pezotettix giornae*.

• The Legs

Each of the six legs comprises a femur, tibia and tarsus (figure 1). The front two pairs (fore legs and mid legs) are very similar whereas the last pair, the hind legs, are always more developed, with swollen hind femurs.



1: Hind legs are always more developed than the front two pairs of legs. An example with the Large Dark Bush-cricket (*Pholidoptera femorata*).

Special features

In most Caelifera the two hind legs bear a comb-like structure on the inner side of the femur, used by grasshoppers use to produce sounds (cf. Stridulation, p. 24). In the Ensifera the **tympanal organs** are located on the hind legs, at the base of the tibia, and are usually elongated (in the shape of a slit) or oval.

• Flight organs

The flight organs are composed of two rather different pairs of wings:

- The **fore wings**, called **elytra** or **tegmina** (singular: tegmen), are narrower and thicker than the hind wings.
- The **hind wings** are thin, membranous and fan-shaped; they are generally transparent but can be brightly coloured in some species (especially in the *Oedipoda*). At rest, they are hidden under and protected by the elytra, folded longitudinally along the main veins.

The tegmina and hind wings comprise veins and "areas". The morphology of the veins and areas of the tegmina is an important criterion for species identification (figure 4).

In the Ensifera, stridulatory organs are found on the tegmina; they are called the "harp" in crickets and mole-crickets and the "mirror" in bush-crickets (cf. Stridulation p. 24). The flight organs are more or less developed depending on the species. Winged individuals normally fly well. This is particularly true for grasshoppers, where some species perform migrations over several hundred kilometres. Some species, on the other hand, have well developed wings but rarely fly, as they are too heavy to do so.

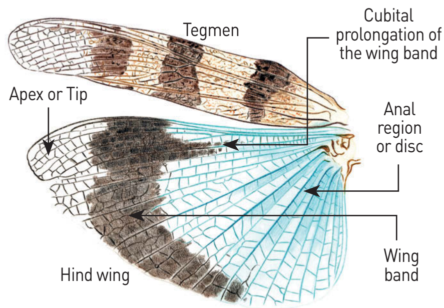
The following distinctions can be made:

- **apterous species**: absence of flight organs,
- **micropterous species**: small tegmina, covering less than half of the abdomen, overlapping partly or fully on the back; hind wings absent or greatly reduced. **Squamipterous species** can be linked to this group (wings absent; tegmina separated on the back; tegmina lobe scale - or shield-shaped),
- **brachypterous species**: tegmina generally shorter than the abdomen; they may touch or overlap on the back; hind wings reduced,
- **macropterous species** or **individuals**: with well-developed flight organs (tegmina and hind wings of equal length, generally exceeding the tip of the abdomen). In some species of the subfamily Phaneropterinae, the hind wings extend behind the tegmina when at rest; these are called **parapterous species**.

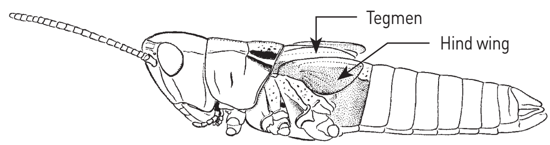
Note: in some micropterous or brachypterous species, abnormal winged forms are sometimes observed (figure 5).

It can be difficult to distinguish between adults and larvae of apterous species. Larvae of apterous species are smaller and the reproductive organs (cerci and ovipositor) are not yet fully formed. Similarly, for the beginner, it can be difficult to identify the larvae of winged species: at the last larval stage, some possess well-developed wing sheaths, and they can resemble a micropterous or brachypterous species. The wing sheaths are, however, triangular in shape; the vein structure is also simpler and can relatively easily be distinguished from that of an adult (figure 3).

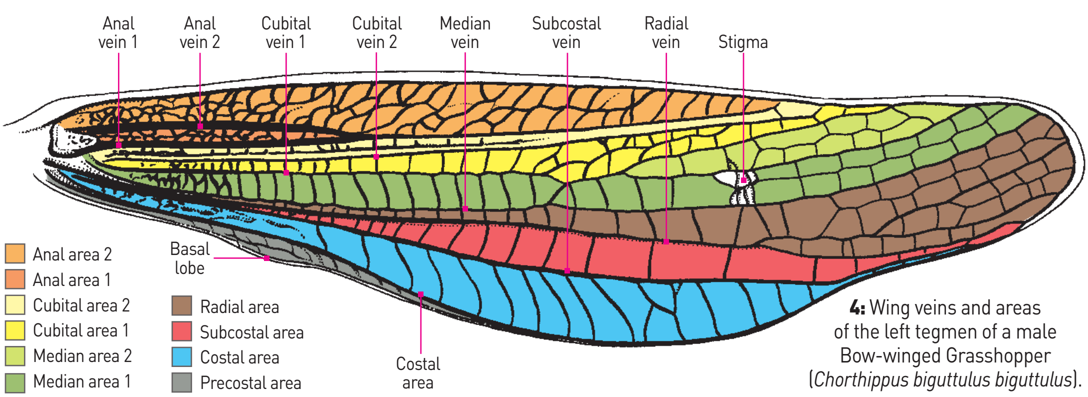
In the particular case of species of *Tetrix* groundhoppers, larvae are very similar to adults. It is, however, possible to separate larvae from adults by looking at flight organs: the larvae have no visible flight organs (the wing sheaths are hidden by the pronotum). Moreover, the lateral lobes of the pronotum each bear two notches in adults, but only one notch in larvae (figures 6 and 7).



2: Tegmen and membranous hind wing of a grasshopper: Blue Band-winged Grasshopper (*Oedipoda caerulescens*).

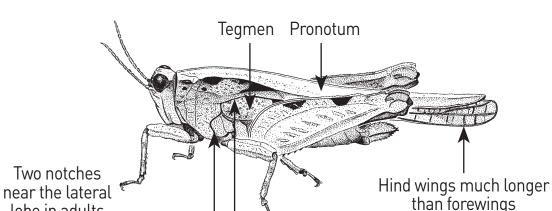


3: Wing sheaths of the larva of the Gravel Grasshopper (*Chorthippus pullus*): tegmen in reverse position relative to the wing. The tegmina are located below the wings during the last two larval stages.

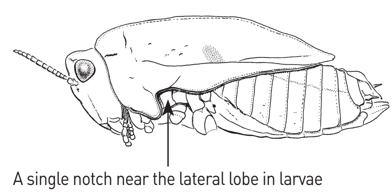


4: Wing veins and areas of the left tegmen of a male Bow-winged Grasshopper (*Chorthippus biguttulus biguttulus*).

5: Various wing sizes in the Small Gold Grasshopper (*Euthystira brachyptera*)



6: Adult Cepero's Groundhopper (*Tetrix ceperoi*).



7: Larva of the Two-spotted Groundhopper (*Tetrix kraussi*).

THE ABDOMEN

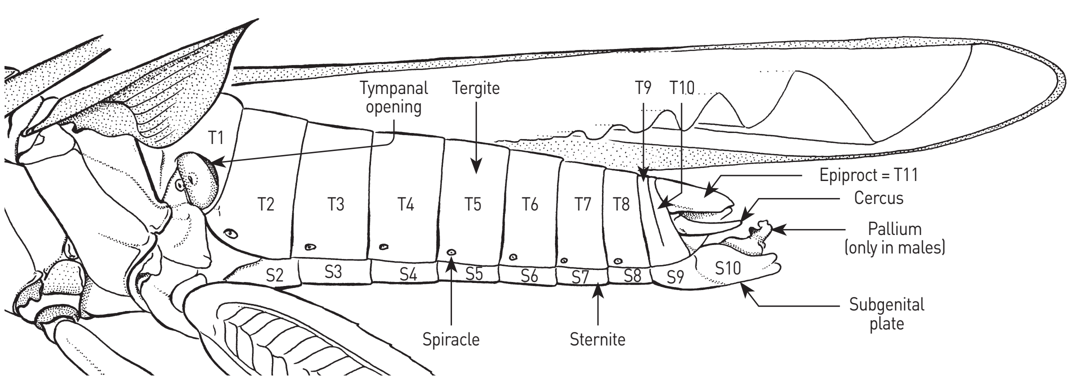
The abdomen is the largest part of the body of Orthoptera. It contains most of the digestive system and all the reproductive organs. The abdomen is made up of segments, which allow for its expansion; each segment bears two types of plates: the tergites (dorsal) and the sternites (ventral) (figure 1).

The tip of the abdomen ends with a subgenital plate.

Grasshoppers also possess tympanal openings at the base of the abdomen, on the first tergite. Respiration occurs through the spiracles, placed on each side of the tergites (figure 1); they are small holes that open and close according to respiratory needs.

At the tip of the abdomen, there are:

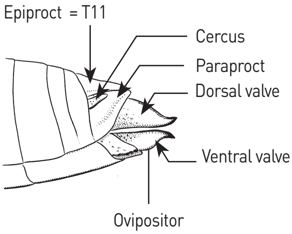
- Two lateral **paraprocts** and a dorsal **epiproct** arranged around the anal opening (figures 2, 3, 4 and 5).
- Two **cerci** in a latero-dorsal position. In grasshoppers they are simple, taking the shape of more or less elongated cones (figure 3). In crickets, they are straight and elongated. In bush-crickets, the cerci are simple and short in females, whereas in males the shape depends on the species: they can be sharply curved, bear a tooth or be highly modified (figure 7). The cerci enable the male and the female to remain together during mating.
- The **subgenital plate**. In male grasshoppers, as opposed to male bush-crickets, the subgenital plate wraps around the tip of the abdomen and turns upwards, giving the tip of the abdomen a rounded or sometimes slightly elongated shape (in *Euchorthippus*, *Chrysochraon*, *Acrida*). Male bush-crickets nearly always bear a short, straight subgenital plate, more or less notched at its apex and extended by two styles (figure 5). Crickets do not possess styles and simply have a rounded subgenital plate (rarely notched). The aspect and shape of the subgenital plate often provide reliable identification criteria (soft or hard plate, notched or not, ridged, etc.).
- **Titillators**, present only in males of the Ensifera, are two (or sometimes two pairs) of small, symmetric and sclerified (hard) body parts, often curved and bearing small teeth (figure 8). They are largely hidden at the end of the abdomen, with only their tips visible between the subgenital plate and the cerci (figure 5). It is sometimes necessary to extract them in order to examine properly, especially for the identification of *Anonconotus* and *Platycleis*. Note that the Phaneropterinae subfamily is an exception, as they have neither styles nor titillators.
- The **pallium** is a membrane housing the penis in male Caelifera, which constitutes an important identification criterion for the genus *Calliptamus*.
- The **ovipositor**, or female egg-laying organ, is composed of four main valves (except in the genus *Gryllotalpa*, where it is rudimentary). In grasshoppers, the ovipositor is simplified and less variable than in bush-crickets: the valves are thick and short; they end in a more or less curved point (figure 2). In the Ensifera, the ovipositor is much more variable in shape and is essential for identification. It can be very long, narrow, nearly straight, short, thick or very angular (right-angled) and with or without denticulations (figure 6).



1: Detail of abdomen parts in the male Egyptian Grasshopper (*Anacridium aegyptium*).

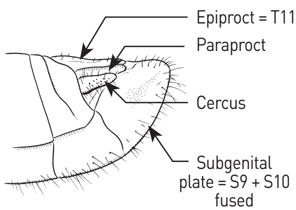
Comparison between the appendices at the tip of the abdomen of Caelifera and Ensifera.

In the Caelifera



Side view

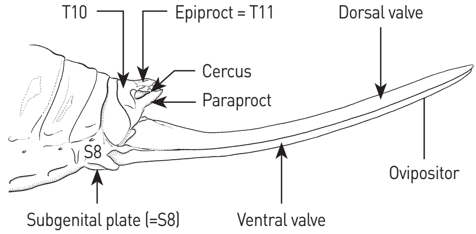
2: Female appendices



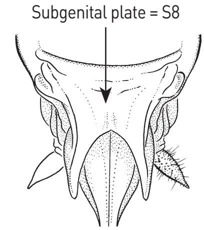
Side view

3: Male appendices male

In the Ensifera

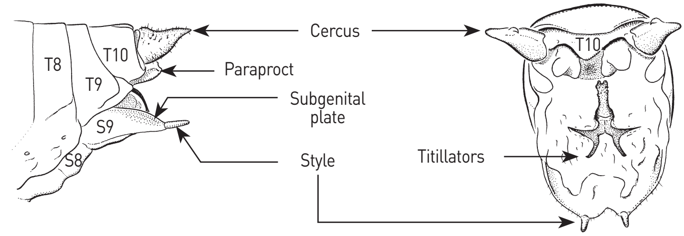


Side view



Bottom view

4: Female appendices

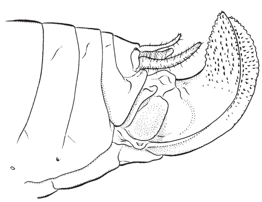


Side view

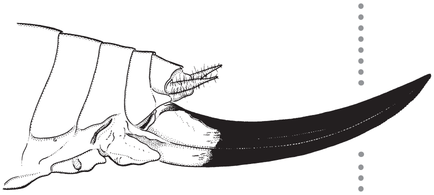
Side view

5: Male appendices

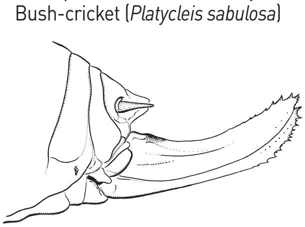
6: Various shapes of ovipositors in female Ensifera



Ovipositor of the Italian Long-legged Bush-cricket (*Acrometopa servillea italica*)

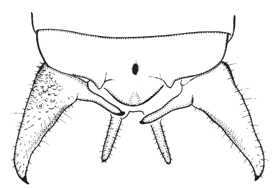


Ovipositor of the Sand Grey Bush-cricket (*Platycleis sabulosa*)

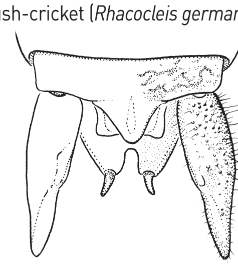


Ovipositor of the Iberian Saw Bush-cricket (*Barbitistes fischeri*)

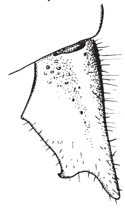
7: Various cerci in male Ensifera



Cerci of the Mediterranean Bush-cricket (*Rhacocleis germanica*)

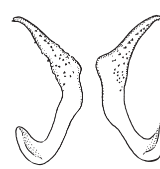


Cerci of the Bei-Bienko's Bush-cricket (*Yersinella beybienkoi*)

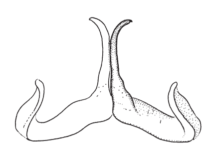


Cerci of the Chopard's Mountain Bush-cricket (*Antaxius chopardi*)

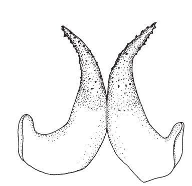
8: Male titillators after extraction



Sand Grey Bush-cricket (*Platycleis sabulosa*)



Common Grey Bush-cricket (*Platycleis albopunctata monticola*)



Common Grey Bush-cricket (*Platycleis a. albopunctata*)

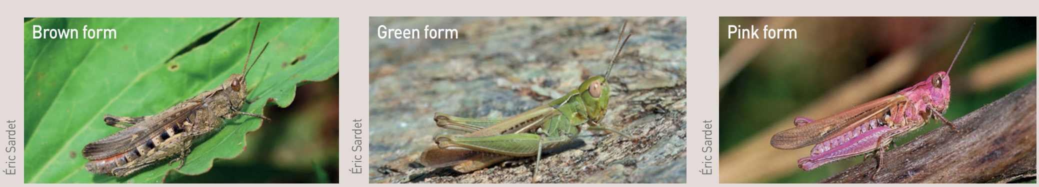
CHROMATIC VARIABILITY

The Orthoptera show great colour variability, especially in grasshoppers where the overall colour can vary between green, brown, red or even violet within the same species (figures 2 and 3). In the case of Tetrix species, the variability is almost infinite in certain cases (figure 1). Colouration is so variable that it is often difficult to use this as a tool for identification.

Experienced orthopterists may have noticed unique colour combinations specific to each species, but these are very hard to describe or to illustrate comprehensively. In order to use colouration for identification, it is therefore necessary to use specific colour traits that are unique and invariable (indicated in the identification keys), as with the vein structure of the tegmina or the shape of the antennae, etc. For species that are normally brown, a larger proportion of green individuals are observed during wet years.

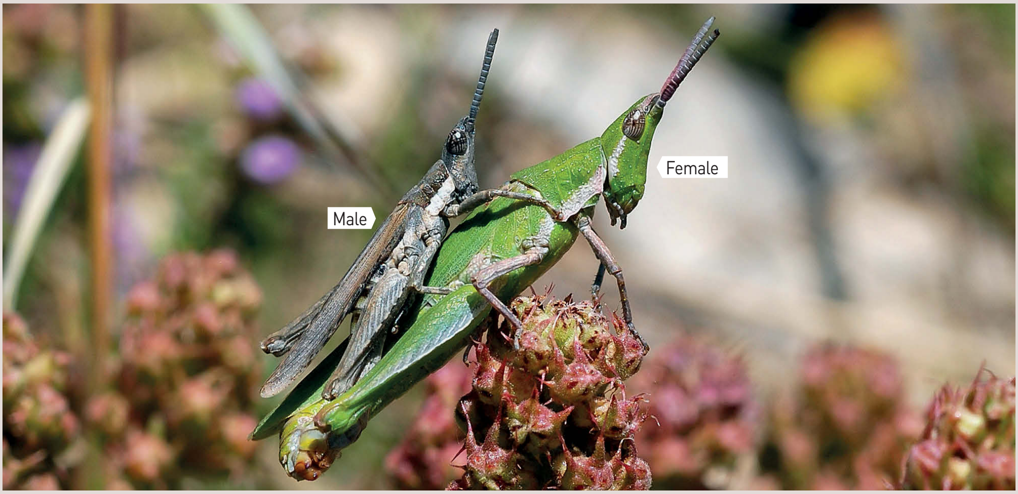
1 : Colour variability in the Mediterranean Groundhopper (*Paratettix meridionalis*).

2 : Colour variability in the Stripe-winged Toothed Grasshopper (*Stenobothrus lineatus*).



3 : Colour variability in the Common Field Grasshopper (*Chorthippus brunneus*).

Some examples of chromatic variability



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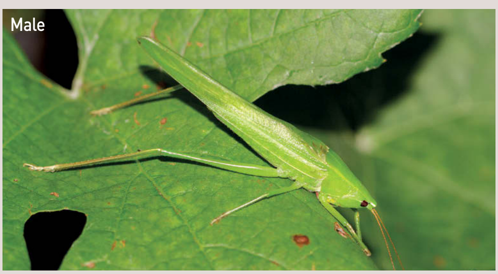
In the Common Stick Grasshopper (*Pyrgomorpha conica*).



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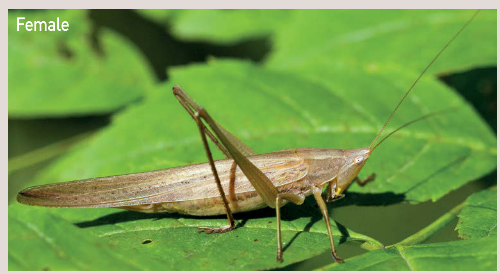

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In the Large Conehead (*Ruspolia nitidula*).

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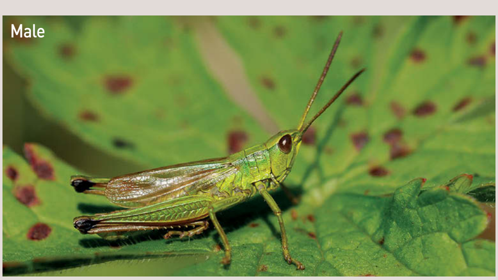
In the Mediterranean Coneheaded Grasshopper (*Acrida ungarica mediterranea*).



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In the Gold Grasshopper (*Chrysochraon dispar*).

Life cycle

All Orthoptera are **hemimetabolous** insects: that is, their development is progressive and the larvae resemble adults without developed wings. Their life cycle can be divided into three main periods: the **embryonic stage** (egg), the **larval stage** (larva or juvenile) and the **adult stage** (imago), which is the reproductive stage.

LARVAL DEVELOPMENT

• Embryonic stage

The embryonic period varies depending on the species, the climatic zone and the year. In the area considered in this guide, the majority of species have only one generation of adults each year; they are called **univoltine**, as opposed to **plurivoltine** (or **multivoltine**: with several generations of adults each year). This latter category is mainly observed in warm regions (Mediterranean zone), where examples of species that exhibit this behaviour include: the Woodland grasshopper (*Omocestus rufipes*), Raymond's Grasshopper (*Omocestus raymondi*) and Common Field Grasshopper (*Chorthippus brunneus*). Certain species, for example the Great Green Bush-cricket (*Tettigonia viridissima*), can have a biannual cycle with one generation appearing every two years.

Depending on environmental conditions, in extreme cases the **embryonic state** can last up to seven years, as is the case for the Common Wart-biter (*Decticus verrucivorus verrucivorus*).

• Larval stage

The embryo leaves the egg as a worm-like larva; it extracts itself from the egg and from the substrate where the egg has been laid by crawling. Once in the open air, the larva immediately undergoes its first moult, called the intermediate moult. The larva emerges from its cuticle (protective membrane) and extends its appendages; these become functional within a few minutes to a few hours. This phase corresponds to the first larval stage (First instar).

In order to become an adult, the larvae go through successive moults, corresponding to as many larval stages as necessary for the sexual and flight organs to gradually develop.

The number of moults and the interval between each moult varies according to the species and the climatic conditions. As an example, for Common Grey Bush-cricket (*Platycleis albopunctata*) the interval is around ten days. Species of the Tettigoniidae family normally have seven larval stages. For a large proportion of species, females, which are always larger than the males, go through one additional moult. Crickets have more larval stages, between seven and fourteen, whereas grasshoppers have only four to six. In the particular case of Groundhoppers (Tetrigidae), there are five larval stages for the male and six for the female.

• Adult stage

After the last moult, called imaginal moult, grasshoppers and crickets enter their adult stage (imago). This last moult allows flight organs to take their final shape.

After this moult, the bodies of the adults are soft and pale. The adults have to dry for several hours or several days in order to gain their definitive adult size and shape, before acquiring their final colouration and becoming sexually mature (capable of reproducing). Only one or two days after the final moult is completed, the males start singing to attract females and mate (cf. Stridulation, p. 24).

PHENOLOGY AND LIFESPAN

In most species a full cycle takes one year. Eggs laid the previous year hatch in the spring (between March and May). The larval stage occurs in the spring and summer, and adults appear between May and September.

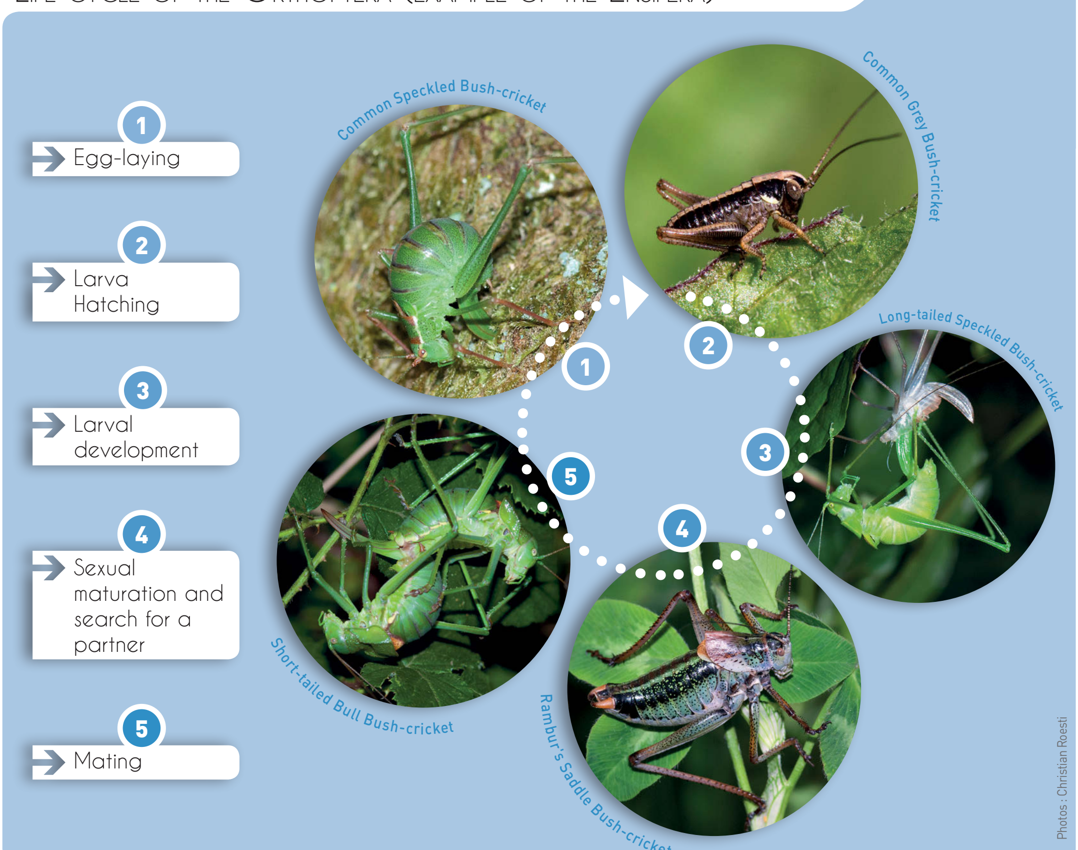
There are, however, exceptions:

- Certain Orthoptera hatch in the same calendar year that the eggs are laid, and overwinter at the larval or adult stage. This is the case in Tetrigidae groundhoppers, in the Common Stick Grasshopper (*Pyrgomorpha conica*), in digging grasshoppers, in species of the *Acrotylus* genus and in certain crickets.
- The Common Field-cricket (*Gryllus campestris*) overwinters in the penultimate or last larval stage and becomes adult during the following spring (after one or two moults).
- The Wood-cricket (*Nemobius sylvestris*) and the Mole-crickets (genus *Gryllotalpa*) can live for up to three years, in which case they overwinter twice (in a larval stage and/or as an adult).

For most Orthoptera, larval and adult life only last a few months; generally between one to three months as larvae, and between one to three months as adults.

Some species, particularly of Caelifera, can live in their adult stage more than six months. Examples include the Broad Green-winged Grasshopper (*Aiolopus strepens*) and the Egyptian grasshopper (*Anacridium aegyptium*). In Bush-crickets, only one species is known to be long-lived, the Shielded Oak Bush-cricket (*Cyrtaspis scutata*); in this species the first adults appear in summer and are still active throughout winter, until early spring. Other species, certain crickets and bush-crickets, such as in the *Myrmecophilus*, *Pseudomogoplistes* and *Troglophilus* genera, can be encountered as adults or larvae throughout the year (corresponding to a continuous life cycle, albeit slower in winter). Most of these species live in relatively constant habitats such as caves and cavities, in ants' nests, in the soil etc., and are therefore less influenced by climatic variations.

Life cycle of the Orthoptera (example of the Ensifera)



MOULT

Throughout larval development, the weight of the body increases continuously. This is particularly visible through an increase in the size of the abdomen. However, the cuticle cannot increase in size and rapidly becomes too small. Moulting allows Orthoptera to shed their cuticle, so that it can be replaced by a new, larger cuticle. During the moult, the individual extracts itself from the cuticle. At that stage, its body is soft, and the insect is unable to escape from danger by fleeing.

Christian Roesti

1: Mould of a female Long-tailed Speckled Bush-cricket (*Leptophyes laticauda*)

Most species suspend themselves from a stem of grass or a leaf in order to moult; the claws of the hind legs cling to the substrate and the individual extracts itself from its cuticle by using body movement, helped by gravity (figure 1). The cuticle splits at the top of the pronotum; the insect first pull its head and the front of its body out of the cuticle, followed by the first two pairs of legs, and last, the hind legs (and in the case of female Ensifera, the ovipositor).

Once the moult is completed, the larva turns around and suspends itself from the substrate by clinging to it with its fore legs. It unfolds its wings and lets them dry in an extended position (figure 2), before folding them behind its body in their final position. Most Ensifera eat their own exuviae after the moult.

Other species, such as Crickets and Groundhoppers moult in a horizontal position, on the ground or while clinging to a substrate (figure 3).

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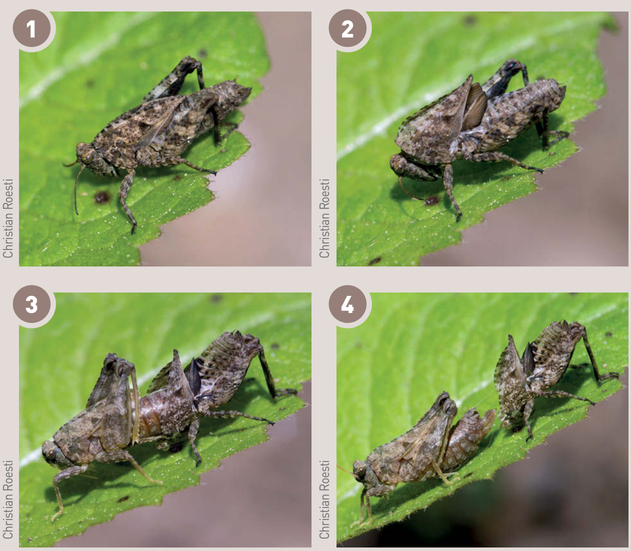
2: Adult moult; transition from larva to adult for a male Great Green Bush-cricket (*Tettigonia viridissima*)



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3: Horizontal moult of a Long-horned Groundhopper (*Tetrix tenuicornis*), stages 1 to 4 in chronological order.

DIFFERENT LARVAL STAGES

Example of the Common Grey Bush-cricket (*Platycleis a. albopunctata*, female)

1. First nymphal instar: the wing sheaths are hardly visible; they form two small humps at the rear of the pronotum. They usually display contrasting colours and are never green.

2. Second nymphal instar: the wing sheaths become more visible; they are rounded in shape with a black centre, underlined with a pale band. The general colour is paler and less contrasted; a greenish colouration, typical of juveniles of *Platycleis* spp. appears on the pronotum and hind legs.

3. Third nymphal instar: the wing sheaths now display a triangular shape but they are still oriented downwards. The underside of the body presents a pale green colouration. The ovipositor of the female is still small but visible.

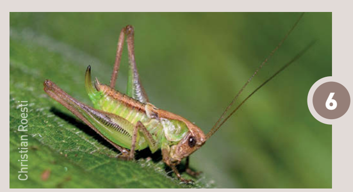
4. Fourth nymphal instar: the wing sheaths start to separate from the thorax. The tegmina are partly hidden under the pronotum, which becomes large and more elongated towards its rear part. The cerci are still of the same size in the two sexes.

5. Fifth nymphal instar: the wing sheaths are still turned downwards. The head and the pronotum are proportionally larger.

6. Sixth nymphal instar: the wing sheaths are free of the thorax and now face upwards. At this stage, the tegmina are hidden by the wings, which are quite visible in a lateral view. The main veins of the wings are already perceptible. The ovipositor is now similar to its final shape.

7. Seventh and final nymphal instar: the wing sheaths are larger than the pronotum; the tegmina are still located on the inner side of the wings.

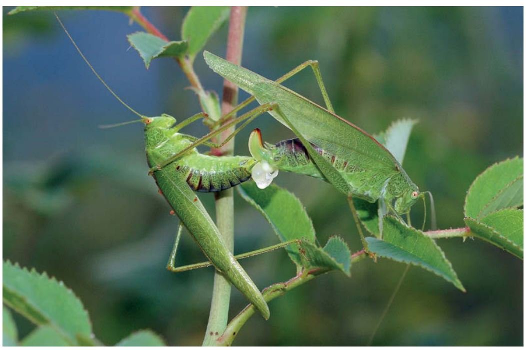
8. Adult stage: the final moult (adult moult) results in the insect taking its adult shape. During this final moult, the tegmina and the wings change position and undergo a deep transformation: the tegmina move outwards and cover the wings; the size and the vein structure of the tegmina and the wings are now final. In the case of the Common Grey Bush-cricket (*Platycleis a. albopunctata*), the general colouration undergoes marked changes, from green to brown. The female ovipositor is of the same size as in the final nymphal instar, but it is now entirely black.



MATING

Mating can last anything from a few seconds to a few hours, depending on the species.

In the Ensifera (bush-crickets and crickets), the female climbs onto the male during mating. The male holds the female with his cerci and fixes his spermatophylax (a white, gelatinous capsule containing the **spermatophore**) under the subgenital plate of the female (figure 1).



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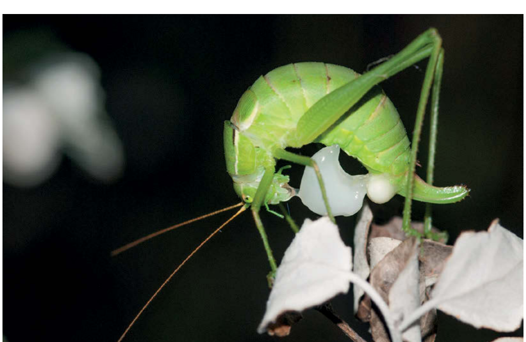
1: Mating in the Ensifera; the Southern Sickle Bush-cricket (*Phaneroptera nana*).

The spermatophore is then partly eaten by the female during insemination (figure 2). Recent research suggests that the spermatophore is of low caloric value, contrary to what was thought in the past. It does, however, reduce the amount of control that the female can have over the insemination, thus assuring a complete transfer of the sperm contained in the spermatophore.



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2: Female eating the spermatophore left by a male Straight-winged Plump Bush-cricket (*Isophya rectipennis*).

Note: in special cases, such as in the Common Predatory Bush-cricket (*Saga pedo*), populations consist exclusively of females that reproduce through parthenogenesis.

In the Caelifera (groundhoppers and grasshoppers), the male climbs onto the female to mate (figure 3); he bends the tip of his abdomen in order to introduce his penis between the subgenital plate and the ovipositor of the female. Spermatozoid transfer occurs during mating, without the presence of a spermatophore.

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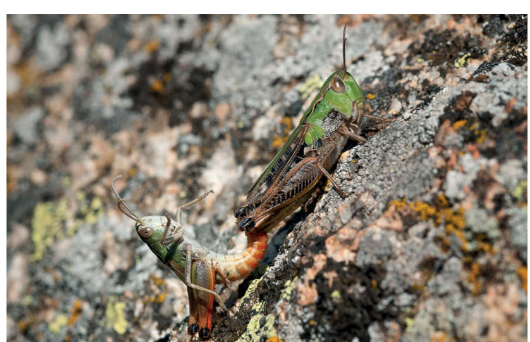
3: Mating in the Caelifera; the Pyrenean Mountain Grasshopper (*Cophopodisma pyrenaea*).

Mating is a vulnerable time for Orthoptera, as it reduces their mobility in the face of predators (this is particularly critical for grasshoppers, in which mating lasts several hours). If disturbed or threatened during mating, the female tries to rid herself of the male by kicking it with her hind legs, so that she can flee. Sometimes the male falls on his back without detaching, and the female moves, dragging the male behind her (figure 4).



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4: An example of mating in which the male has fallen on his back; the Black-spotted Toothed Grasshopper (*Stenobothrus nigromaculatus*).

EGG-LAYING

Once mating has finished and the eggs are inseminated, egg-laying can begin. The female selects a specific substrate in which to insert her eggs using her **ovipositor**. The four valves of the ovipositor can move independently, allowing her to dig in the substrate. The Ensifera also use their mandibles to help orientate the valves in the substrate (figure 5).

Éric Sardet

5: A Pyrenean Mountain Bush-cricket (*Antaxius hispanicus*) laying eggs in forest soil.

The choice of substrate is variable and depends on humidity, granularity, orientation etc. Most Orthoptera species considered in this guide lay their eggs in the ground (figures 6 and 7).

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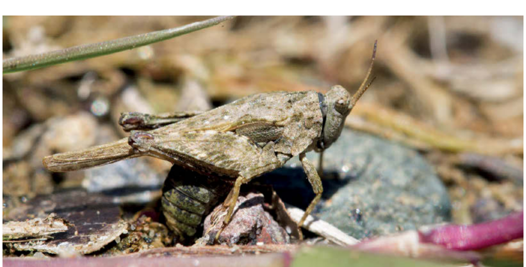
6: A Gravel Grasshopper (*Chorthippus pullus*) laying eggs in moss-covered gravel.



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7: A Bolivar's Groundhopper (*Tetrix bolivari*) laying eggs in damp soil.

Some species do, however, use other substrates: they can lay eggs in tree leaves, tree bark, moss or even in the pith of plant stems (figures 8 and 9).

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8: A Southern Sickle Bush-cricket (*Phaneroptera nana*) laying eggs between the epidermal layers of a leaf.

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9: An Island saddle Bush-cricket (*Uromenus brevicollis insularis*) laying eggs in a stem of Asphodel.

The Small Gold Grasshopper (*Euthystira brachyptera*) has a peculiar behaviour. It lays its eggs in spongy material in the open air, between grasses or among twigs of heather (figure 10).

Martina Katholnig

10: A Small Gold Grasshopper (*Euthystira brachyptera*) laying eggs among twigs of heather.

Song (Stridulation)

One of the most striking characteristics of the Orthoptera is their ability to produce sounds, called songs or stridulations.

Of **the 263 taxa considered in this guide, 206 are able to produce songs (78%), but an important proportion of these songs are difficult to hear (between 24% and 40% depending on the hearing ability of the observer). They often require the use of an ultrasound detector.**

Few insects give audible sound emissions, other than Cicadas and a few moths which make a loud crackling sound when in flight.

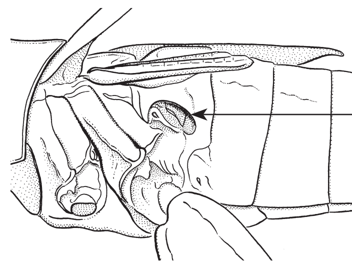
The main function of song is to attract the opposite sex in order to mate and ensure successful breeding. Each species has its own song. A specialist can, just by hearing an individual, identify most singing Orthoptera to species level.

Most non-singing species use other forms of communication. Some make screeching sounds using their mandibles (for example species in the subfamilies Calliptaminae and Melanoplinae).

Certain members of the Tetrigidae family produce vibrations by moving their hind femurs vertically downwards and by hitting their body against the ground or a plant support (such as dead leaves or wood on the ground). However, this phenomenon is still poorly understood. Abdominal stridulation occurs in the Pamphagidae family: they produce sound by rubbing their hind femurs against a rough, striped, shield-like plate located on the side of the second abdominal tergite (Krauss's organ). In this family, the female Dalmatian Stone Grasshopper (*Prionotropis hystrix*) emits a rustling sound to indicate her consent to mate. This sound, even though very brief, is quite loud and resembles a rattle. This type of sound has been heard from taxa in France but never directly observed: it is supposed that it is produced by vigorously rubbing the tegmina one against the other, or against the body. Species in the Meconematinae subfamily, which are small arboreal bush-crickets, drum on leaves or branches using their hind legs, with a distinctive rhythm. Males of some species (in the *Ephippiger*, *Antaxius*, *Barbitistes* genera, as well as some crickets) make their body vibrate to allow female to locate them.

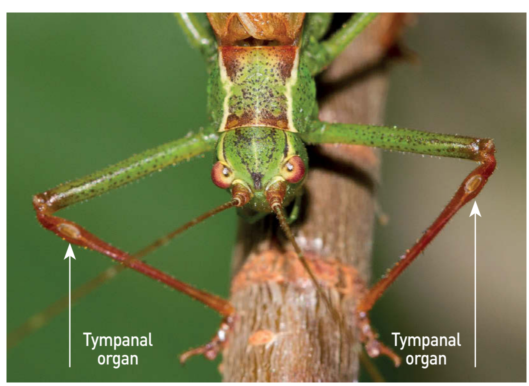
The Orthoptera have very good hearing and can detect sounds over a much wider range of frequencies than those detected by humans.

The hearing organs in grasshoppers are located on each side of the abdomen, towards its base (figure 1).



1: Position of the tympanal organ in the Iberian Meadow Grasshopper (*Pseudochorthippus parallelus erythropus*).

The hearing organs in crickets and bush-crickets are located on the knees of the hind legs (figure 2).



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2: Position of the tympanal organs in the Common Speckled Bush-cricket (*Leptophyes punctatissima*).

Cave-dwelling species lack hearing organs. Communication in these species has been little studied, but it appears to be based on vibrations (drumming with the body and hind legs) and antennal contact.

SONG PRODUCTION

In the grasshoppers and groundhoppers (Caelifera), mechanisms for **sound production** vary with the family. The most complex and spectacular songs are those of the Gomphocerinae, a subfamily that contains a larger number of species. The grasshoppers rub (from top to bottom) the interior of their hind femurs bearing a **stridulatory ridge**, against the tegmina (figures 3 and 4).


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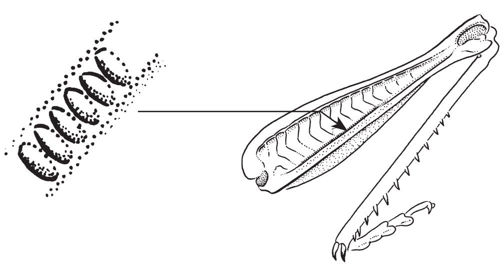
3: Alpine Thick-necked Grasshopper (*Aeropedellus variegatus*) rubbing its femurs against its tegmina.

The stridulatory ridge consists of a line of small, blunt, tooth-like protrusions, more or less spaced depending on the species (figure 4). Sound is produced when the ridge passes over the thickened radial vein of the tegmen.



4: Details of the stridulatory ridge on the hind femur of a grasshopper.

The two hind femurs can move in phase with each other or out of phase. In the latter case, which is the most common one, two superimposed sounds are produced. Several species of Gomphocerinae produce crackling sounds with their wings, in flight or on the ground, as is the case in the Ladder Grasshopper (*Stauroderus scalaris*), the Large Banded Grasshopper (*Arcyptera fusca*), the Speckled Buzzing Grasshopper (*Bryodemella tuberculata tuberculata*), and the Wing-buzzing Toothed Grasshopper (*Stenobothrus rubicundulus*) (figure 5).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5: A Wing-buzzing Toothed Grasshopper (*Stenobothrus rubicundulus*) rattling its wings.

In the Locustinae (=Oedipodinae) subfamily, a similar mechanism is used, but the sound is produced by the veins interposed in the median area, which possess small teeth (in the absence of a stridulatory ridge); as a consequence the sound produced is often hardly audible.

A few species, such as the Large Marsh Grasshopper (*Stethophyma grossum*) emit a rattling sound, by rapidly moving the spurs present on the hind tibia over the veins of the tegmen.

In the crickets and bush-crickets (Ensifera), stridulations are produced by rubbing the two tegmina against one another. The stridulatory organ is located at the base of the tegmina, behind the pronotum (figure 6).

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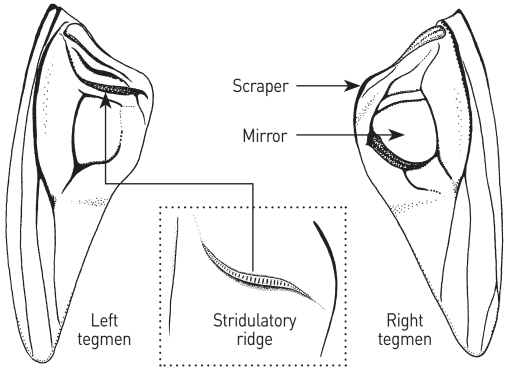
Christian Roesti

6: Common Speckled Bush-cricket (*Leptophyes punctatissima*) rubbing its two tegmina together.

The stridulatory organ consists of a toothed ridge (the **stridulatory ridge**) located on the underside of the tegmen, and of a thickened edge (or **scraper**) on the other tegmen (figure 7, following page). The ridge is found on the left tegmen in bush-crickets and on the right tegmen in crickets.

The sound is amplified by special parts of the tegmen: the mirror in the bush-crickets; the mirror and the harp in crickets and mole-crickets.



7: Lower surface of the tegmina of a Purple Meadow Bush-cricket (*Metrioptera saussuriana*).

During stridulation, the pronotum and the tegmina are slightly raised. In mole-crickets and most crickets, the tegmina are raised almost perpendicular to the body; the intensity of the sound forces the insect to cling to the ground or to a plant support (figures 8 and 9).

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8: A Common Field-cricket (*Gryllus campestris*) lifts its tegmina in order to produce a song.

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9: A European Tree-cricket (*Oecanthus pellucens*) lifts its tegmina perpendicular to the body in order to produce a song.

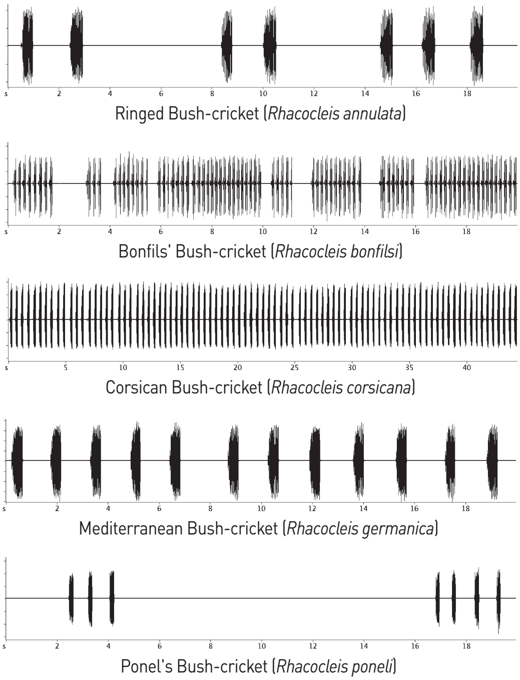
SONG TYPES AND THEIR DESCRIPTION

Song is mainly produced by males. Organs used for stridulation are poorly developed in females. However, in several groups, such as in the subfamily Phaneropterinae, females respond to males in order to locate each other. Song can also be produced to indicate a refusal to mate, or on the contrary an acceptance.

Songs have several functions. In males, the **advertising song** (**calling song**) is used to attract a female, whereas the **duetting song** is produced in the presence of the female, with the aim of mating. The advertising song is often produced alternatively when two males find themselves close to each other but without visible contact (alternating song). The encounter between two or more males provokes different types of song: a **fighting or rivalry song** (between males), but also a **defensive song** (if a male is already mating). The **courtship song** (short, excited strophes), precedes the **assault song** (the male literally jumps onto the female for mating). Finally, the **warning song** appears to be specific to the Ensifera.

As a result, a single species can produce a large variety of sounds. Their rhythm, their frequency and the song structure are specific to each species and offer a useful tool for specific identification. From recordings, it is possible to produce oscillograms and sonograms (song diagrams) in order to visualise and characterise the song structure (figures 10 and 11).

The British authors Ragge & Reynolds (1998) published a comprehensive work on European Orthoptera, proposing in certain cases a taxonomic revision based on stridulations (they consider that if the stridulations of two species are identical, they must belong to a single species). The authors meticulously described the structure of the song, from the longest sequence to the shortest. The complete song is composed of a series of verses (or echeme-sequence); each echeme-sequence comprises a number of phrases (echemes) and each phrase consists of accents (syllables).



10: Oscillograms of five species of *Rhacocleis*.

In the Ensifera, an accent (syllable) corresponds to the complete opening and closing of the tegmina, whereas in the Caelifera, the accent corresponds to a back and forth movement of the hind femur on the tegmen (from top to bottom).

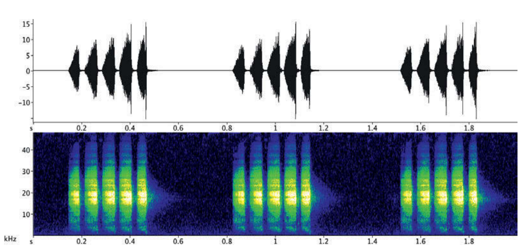
A more recent approach examines the electro-magnetic waves of stridulations. This new discipline derives from the use of ultrasound detectors commonly used to study bats. These detectors are particularly useful to find crickets producing high frequency sounds, which are inaudible to the human ear above 20 kHz. Our hearing acuity decreases rapidly with age (from the age of 30 to 40, depending on the individual) and a large number of species are no longer audible for those over 60 years old. Crickets are generally more easily detected because their songs are produced at lower frequencies (around 2 to 8 kHz). In this group, the clear tone of the song leads to the conclusion that the frequency of emission is important in intra-specific recognition.

In bush-crickets, it appears that emission frequencies are less important; the structure of the song probably plays a more important role in intra-specific recognition, whereas in grasshoppers it would appear that frequency is of little importance.

The frequencies can be translated into a graph representing the energy spectrum; this allows the characterisation of the dominant frequency – the frequency that carries the maximum sound energy (figure 11).

The dominant frequency is probably useful for characterising the song of a species. However, our current knowledge of the role of these frequencies is still limited, and more research is needed. It is important to note that the frequencies and the structure of the song can vary greatly with the ambient temperature. The muscle action speed (or activity rhythm) in Orthoptera depends on the external temperature, as they are poikilotherms (their body temperature varies with that of their environment). Speed increases with rising temperatures; at low temperatures the rhythm is much slower and sometimes difficult to recognise, especially in the Ensifera. This is, for example, the case for the Upland Green Bush-cricket (*Tettigonia cantans*) or for the Common Grey Bush-cricket (*Platycleis a. albopunctata*).

In some rare cases, the diurnal and nocturnal songs (independently of temperature) are very different in the same species, as for example in Vichet's Bush-cricket (*Amedegnatiana vicheti*).



Christian Roesti

11: Diurnal song of the Common Grey Bush-cricket (*Platycleis albopunctata grisea*), photo above right.
Above left: an oscillogram; below that: a sonogram.

Survey, observation and photography

SURVEYING AND REGULAR MONITORING

The production of lists of species through Orthoptera surveys can help determine the **species richness** of a habitat. Surveying allows for the identification of rare or threatened species. Species richness or diversity also provides an indication of the diversity of habitats and of the ecological potential of a site. The quality of an initial survey (or assessment) is very important, because it informs as to the significance of any future surveys. Surveys generally aim to evaluate population changes over time, by measuring the changes between the initial baseline survey and following surveys. The aim can be, for example, to measure at a local level the effects of management practices over a short period of time, or to study the medium-term consequences of climate change.

Orthoptera react quite rapidly to changes in habitat structure, with a change in species diversity. They do, however, possess a certain degree of resilience to environmental changes; it appears that they are less likely to become locally extinct than butterflies, for instance. Indeed, Orthoptera species can continue to survive in very small patches of habitat with low populations. Regular surveys can be particularly useful to measure medium- or long-term changes. These data allow orthopterists to evaluate the vulnerability of various species, especially of red listed species.

Knowledge of the Orthoptera in **Western Europe** is evolving quickly, notably with the development of regional atlases. For example, two atlases to French Orthoptera have been published (Voisin, 2003 and Defaut et al., 2009), both based on incomplete data at that time. In this present work we have tried to update the maps of species distribution, with the proviso that some areas are still very much under-recorded. The other countries considered in this guide all have their own national atlases and better-structured national knowledge bases. **Switzerland** has set a benchmark in the field with a national organisation, the "Centre Suisse de Cartographie de la Faune (CSCF)", which centralises and analyses fauna records, including for Orthoptera, on a national scale. The CSCF has published an online distribution atlas. In addition, there are three guidebooks and an application for smartphone and tablets offering easy access to distribution maps of the Orthoptera of Switzerland. An atlas was published for **Belgium** in 1997, and the website of the Benelux Orthoptera study group (Saltabel) proposes regularly updated distribution maps. A national atlas was produced for **Luxembourg** in 2004 and distribution maps are also available online. An *Atlas of Grasshoppers, Crickets and Allied Insects in Britain and Ireland* was produced in 1997 by E.C.M. Haes and P.T. Harding. *Field Guide to the Grasshoppers of Great Britain and Ireland* by Peter Sutton and Björn Beckmann, and illustrated by Richard Lewington, is forthcoming from Bloomsbury in 2022.

WHERE, WHEN AND HOW TO OBSERVE ORTHOPTERA

• Where to see Orthoptera

In the area considered in this book, Orthoptera are present in all terrestrial habitats, at altitudes ranging from sea level to more than 3,000 m. They occur in wetlands as well as in the driest habitats. In addition, a few species are troglophiles, living in natural or artificial cavities and crevices.

Orthoptera show a high adaptability to anthropic habitats, and can therefore be found in towns and industrial sites. Urbanisation even has a positive effect on a small number of species. Large urban areas offer milder winter temperatures (mesoclimate), allowing certain species to expand their range northwards. This has been the case for the Southern Oak Bush-cricket (*Meconema meridionale*) and the Southern Sickle Bush-cricket (*Phaneroptera nana*). A few introduced species also maintain populations in urban microclimates, in buildings, in heated greenhouses or even in underground transport networks, as is the case in Paris. The most common ones are the aptly named House-cricket (*Acheta domesticus*), the Greenhouse Camel-cricket (*Diestrammena* (*Tachycines*) *asynamora*) and the Tropical House-cricket (*Gryllodes sigillatus*).

Pioneer species also benefit from human activity: capitalising on gravel pits, quarries, car parks, coal mine pitheads, slagheaps and earthworks. These habitats favour the dispersion and the colonisation by pioneer species such as the Blue-winged Sand grasshopper (*Sphingonotus caerulans*), the Blue Band-winged Grasshopper (*Oedipoda caerulescens*), the Verge-cricket (*Eumodicogryllus b. bordigalensis*), the Mottled Grasshopper (*Myrmeleotettix maculatus*) and so on.

In general, agricultural activity has a negative impact on Orthoptera, particularly in the case of intensive crop farming. However, a few practices can be beneficial, or at least be favourable to some species, especially grazing that maintains open habitats (grassland, meadows). Extensive crops and orchards are often home to a reduced group of species but that may be quite specific.

Forest habitats are generally less favourable for the observation of Orthoptera; and compared to tropical regions, no species in the area considered in this guide is strictly a forest specialist. Although arboreal species such as the Oak Bush-cricket (*Meconema thalassinum*), the Shielded Oak Bush-cricket (*Cyrtaspis scutata*) or the Common Saw Bush-cricket (*Barbitistes serricauda*) are observed in woodland, they are not restricted to forests and they can also be encountered on isolated trees in otherwise open habitats.

Unlike butterflies, Orthoptera are not linked to specific host plants, with one exception in France: the Red-legged Grasshopper (*Chorthippus binotatus binotatus*), which always occurs in areas with clumps of broom or gorse.

Dry, warm habitats are often richer in species. As a consequence, species diversity increases considerably in the south of the area considered in this book; Mediterranean areas have the highest species richness. In mainland France, the number of species increases progressively from the North to the South. Just 32 species have been recorded in the Nord department (comparable to the UK's total of 27 native species), by contrast with 139 in the Pyrénées-Orientales. Species diversity also decreases quite rapidly with altitude, especially above 2,000 m. Only a few species adapted to the challenging climatic conditions are able to survive above 2,500 m.

The distribution of Orthoptera is explained mainly by climatic conditions, by the presence of specific habitats (water courses, gravel or sand banks, saltmarsh, etc.) and of course by biogeography, that is, the history of species distribution during the ice ages. Linked to the locations of various glacial refugia, the recolonisation of the area covered in this book has followed very different scenarios depending on the species concerned. Besides, rivers and mountain chains function as insurmountable barriers for species that are incapable of flying.

In the area considered here, the main centres of endemism are Corsica and the large mountain ranges (the Alps and the Pyrenees). There are 15 species and 16 subspecies endemic to France; and one species endemic to Switzerland, Keist's Plump Grasshopper (*Podismopsis keisti*).

• When to observe Orthoptera

Orthoptera are visible during most of the year, with a maximum of individuals observed in their adult stage between June and October, which corresponds to the life cycle of most species. In areas with a mild winter climate, Orthoptera can be observed all year round. There is, however, a lower species diversity and limited activity between November and March. Orthoptera observed during this period may correspond to late-emerging individuals, but more often than not to species with a staggered phenology. Adults or late-stage larvae overwinter and reproduce in the following spring, with the next generation of adults appearing the following summer or autumn.