Journal of Food Safety and Food Quality 67, Heft 1 (2016), Seiten 1–28

Arch Lebensmittelhyg 67,
4–11 (2016)
DOI 10.2376/0003-925X-67-4

ISSN 0003-925X

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Practical key to identify entire edible insects sold as foodstuff or feedstuff in central Europe

Praktischer Bestimmungsschlüssel für in Mitteleuropa als Lebens- oder Futtermittel erhältliche, essbare Insektenarten

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Summary

In 2014, edible insects have been introduced officially into the European Union market in Belgium and the Netherlands as foodstuffs, presenting national regulations in order to ensure food safety. Entomophagy is also practiced, on a small scale, in other EU countries, e. g. Germany. Consumers and public health staff are interested in knowing more about this foodstuff, and identification of edible insects is one of the information fields that have to be attended. Insects are usually identified using scientific keys, but the specialized nomenclature to describe exterior features makes this a job for experts. The present key is intended to be used also by non-experts, addressing 18 insects species that are either part of the official Belgian and/or Dutch list for insects that are tradable as foodstuffs or are available in German pet shops from where consumers may buy them, rededicating a feedstuff knowingly and at their own risk to a foodstuff. As a preliminary evaluation, the key was offered students of veterinary medicine. They were asked to identify some insect with this key and to rate it with a score from 1 (very easy) to 6 (impossible). Students worked with n = 20 insect specimens rating the key with mean score of 1.85 ± 0.72. The key presented here includes the improvements as suggested by the students.

Keywords: crickets, locusts, mealworms, *Bombyx mori,* caterpillars

Zusammenfassung

2014 wurden essbare Insekten offiziell auf dem Lebensmittelmarkt der Europäischen Union in Belgien und den Niederlanden zugelassen, die nationale Verordnungen zur Gewährleistung der Lebensmittelsicherheit erlassen haben. Entomophagie wird in geringem Umfang auch in anderen EU-Ländern praktiziert, z. B. in Deutschland. Verbraucher und Angestellte aus der Veterinärverwaltung haben ihr Interesse geäußert, mehr zu diesem Lebensmittel zu erfahren, und die Bestimmung essbarer Arten ist einer der Wissensbereiche, die angesprochen werden müssen. Insekten werden herkömmlicherweise mithilfe wissenschaftlicher Schlüssel bestimmt, deren Spezialvokabular zu Beschreibung des Exterieurs das zu einer Aufgabe für Experten macht. Der vorliegende Bestimmungsschlüssel soll auch von Laien in der Materie genutzt werden können und befasst sich mit 18 Arten, die entweder auf der offiziellen belgischen bzw. niederländischen Liste zum Handel freigegebener Arten stehen oder in deutschen Zoofachgeschäften erhältlich sind, aus denen Verbraucher sie für den Eigenverzehr kaufen und damit wissend und auf eigene Gefahr ein Futter- zu einem Lebensmittel umwidmen. Im Zuge einer Vorabbeurteilung wurde der Schlüssel Studierenden der Tiermedizin vorgelegt. Sie wurden gebeten, mit seiner Hilfe Insekten zu bestimmen und die Leichtigkeit in einem Punktesystem von 1 (sehr leicht) bis 6 (unmöglich) zu bewerten. Die Studierenden arbeiteten mit n = 20 Insektenexemplaren und bewerteten den Schlüssel im Mittel mit 1,85 ± 0,72 Punkten. Der hier vorgestellte Bestimmungsschlüssel beinhaltet die Verbesserungsvorschläge der Studierenden.

Schlüsselwörter: Grillen, Heuschrecken, Mehlwürmer, *Bombyx mori,* Raupen

Introduction

The FAO has been promoting edible insects on a world-wide scale for several years as one of many ways to ensure sustainable human nutrition for the next decades (van Huis et al. 2013). In Europe which is characterised by a culture-based reproach towards most insects (despite isolated cases in which insects are resp. were consumed), this food habit is still not very well-established. The fact that edible insects and products derived from them (with the exception of honeybee-derived products, cochineal and shellac resp. lacquer) have not been addressed as such in current EU legislation also creates a certain degree of uncertainty on how to ensure food safety.

Still, awareness of edible insects does exist in the European Community (EC). As a visible result of the wish to consider edible insects as a regular foodstuff, the governments of Belgium and the Netherlands issued national frameworks to permit the usage of insects as a foodstuff[1]). Both countries issued lists with insect species the framework refers to. These lists differ from each other. While Luxemburg declined from this option, Switzerland is very active to include insects in their legal framework soon (Halloran et al., 2015). Recently, the European Food Safety Authority issued a scientific opinion on edible insects[2]), and the amendment of the novel food regulation which may include insects has started to come into reach[3]), so the condition while writing this contribution may change in the future.

Also in Germany, the authors observed interest for this novel product from consumers (at tasting events) and public health veterinarians alike, but in contrast to Belgium and the Netherlands, a corresponding national legislation is still missing. In many conversations which the authors had with the interested public, it became obvious that there is also uncertainty on which insect species are edible and how to identify them. In fact, the amount of species regarded as edible varies between approx. 1,000 and 3,000 (van Huis et al., 2013). The University of Wageningen has edited an online list[4]) on edible species worldwide. Of those, only a few are known in Europe and have the potential to become "common" edible insects. Among them, there are some cricket, locust, and mealworm species that are already sold in Belgium and, in part, in the Netherlands. Some retail shops specialized in Asia food also offer frozen silk worm *(Bombyx mori)* pupae by the name of "ground cucumber" or "Nhộng Vàng". People in Germany who want to taste insects may buy living insects at pet shops that are normally destined as feed for insectivorous animals, e. g. reptiles or amphibians. By doing so, they knowingly (i. e., at their own risk) rededicate a feedstuff (as stated frequently on the packages) into a foodstuff.

Identification keys are a classical method for biologists to identify a given organism. As they may refer to small details of their outer structures, dominating this corresponding anatomical vocabulary and being experienced in identifying and evaluating these structures, working with identification keys is usually a task for specialists. However, many consumers and veterinarians working in the public sector do not have this skill.

The objective of this contribution is therefore to provide a practical key to identify those entire edible insects that can be obtained either as a foodstuff or a feedstuff. It is meant for non-specialists who want to identify a given (entire) edible insect. As it is designed to only tell the species mentioned here from each other, it has got an incomplete coverage insofar as other (possibly edible) species are not considered.

TABLE 1: *Edible insect species contemplated in the identification key, the consumed instar (i. e., the phase of the life cycle), and their relevance in Belgium (B) or the Netherlands (NL) as foodstuff, resp. in Germany (D) as a feedstuff.*

Order, species		Instar	B	NL	D
Locusts, grasshoppers, and crickets (Orthoptera)					
(African) migratory locust	*(Locusta migratoria)*	nymph, adult	x	x	X
American (desert) locust	*(Schistocerca americana)*	adult	x		
Desert locust	*(Schistocerca gregaria)*	nymph, adult			x
House cricket	*(Acheta domesticus)*	adult	x		
(Jamaican) field cricket	*(Gryllus assimilis)*	adult	x		
Mediterranean/two-spotted cricket	*(Gryllus bimaculatus)*	nymph, adult			x
Banded cricket	*(Gryllodes sigillatus)*	adult	x		x
Moths (Lepidoptera)					
Greater waxmoth, waxworm	*(Galleria mellonella)*	caterpillar	x		x
Lesser waxmoth, waxmoth worm	*(Achroia grisella)*	caterpillar	x		
Silkmoth, silkworm	*(Bombyx mori)*	caterpillar, pupa without cocoon	x		x
Tebo/butter worm	*(Chilecomadia moorei)*	caterpillar			x
Beetles (Coleoptera)					
(Yellow) mealworm	*(Tenebrio molitor)*	larva	x	x	x
Superworm	*(Zophobas atratus)*	larva	x		x
Lesser/buffalo worm	*(Alphitobius diaperinus)*	larva	x	x	
Litter/black fungus beetle, lesser mealworm	*(Alphitobius laevigatus)*	larva	x		
Sun beetle	*(Pachnoda* spp.)				x
Bees, wasps, ants (Hymenoptera)					
Honeybee	*(Apis mellifera)*	larva, pupa			x
Flies (Diptera)				x	
Black soldier fly	*(Hermetia illucens)*	(pre)pupa			x

Materials and Methods

Species selection

The list of edible insects in this key (Tab. 1) is based on the insects that are legally on the market as foodstuffs in Belgium and the Netherlands. However, it also includes edible species as available at German pet shops as well as bee brood.

Table 1 shows that some species have several English names, and "lesser mealworm" can refer to different species. It is therefore advisable to use the scientific names.

[1]) http://www.afsca.be/foodstuffs/insects/_documents/2014-05-21_Circular_insects_version11_EN.pdf
http://www.favv-afsca.fgov.be/scientificcommittee/advices/_documents/ADVICE14-2014_ENG_DOSSIER2014-04.pdf
https://www.nvwa.nl/txmpub/files/?p_file_id=2207474

[2]) http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/4257.pdf

[3]) http://www.europarl.europa.eu/RegData/etudes/ATAG/2015/569022/EPRS_ATA%282015%29569022_EN.pdf

[4]) http://www.wageningenur.nl/upload_mm/8/b/7/a024c922-766e-47b9-888e-e35d7f613634_World%20list%20of%20edible%20insects%20%28Jongema%2C%202014%29.pdf

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FIGURE 1: *Tenebrionid larvae, from left to right: Zophobas atratus (morio), Tenebrio molitor, Alphitobius diaperinus; as can be seen, the different species vary visibly in their sizes.* Picture: Grabowski

FIGURE 2: *Tenebrio molitor, larvae; the bifurcation can only be seen with magnifying glasses.* Picture: Grabowski

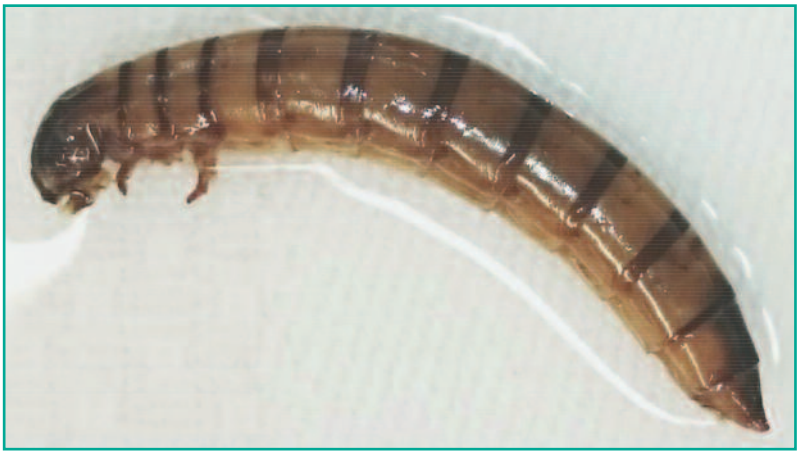

FIGURE 3: *Zophobas atratus (morio), larva.* Picture: Grabowski

FIGURE 6: *Pachnoda marginata, grub.* Picture: Grabowski

FIGURE 4: *Alphitobius diaperinus, larvae.* Picture: Grabowski

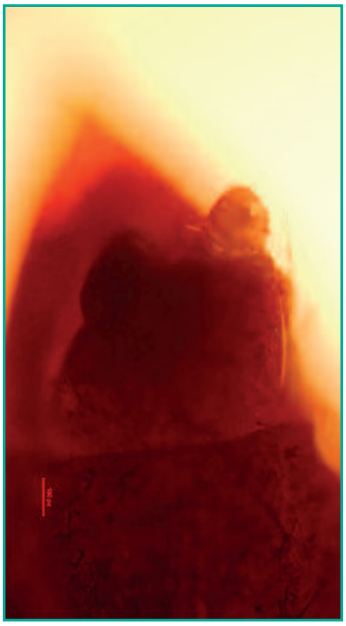

FIGURE 5: *Alphitobius diaperinus, tail segments; note the length of the bristles that do not surpass the tip of the last segment* Picture: Ahlfeld

FIGURE 7: *Chilecomadia moorei, caterpillar.* Picture: Grabowski

Identification key elaboration

The key was designed based on Friederich and Volland, 1992; Schistocerca Information Site, 2009[5]); Spilman, 1991, and Weisman, 1991. In order to keep it practical, a single-access key structure with dichotomous (two options per level) and polytomous (more than two options per level) decisions was chosen. The model contains diagnostic (i. e. differentiation by mere exterior, without considering taxonomical relationships) and, at later stages, some synoptic (i. e. differentiation following taxonomy) keys.

It started with building major groups that are also easily recognisable by the general public, i. e., holometabolous[6]) larvae or pupae ("worms"), and more typical, "real insects", i. e. imagines and hemimetabolous[7]) nymphs. From there,

FIGURE 8: *Galleria mellonella, caterpillar; breathing spiracles may be appreciated at the lateral sides of the animals macroscopically, spiracle morphology however only via magnifying glasses.* Picture: Grabowski

FIGURE 10: *Hermetia illucens, prepupa; the elongated mouth parts along with the clear segmentation and dark colour makes this species and instar easy to tell from other edible insects.* Picture: Grabowski

[5]) http://www.schistocerca.org/key.htm

[6]) Holometabolous: insects that go through a complete metamorphosis in which the pre-imago phases do not resemble the imagines, e. g. beetles, moths, flies and honeybees

[7]) Hemimetabolous: insects that in larval/nymph stage already resemble imagines, and which do not have a quiescent phase (pupa), e. g. crickets, locusts, and termites

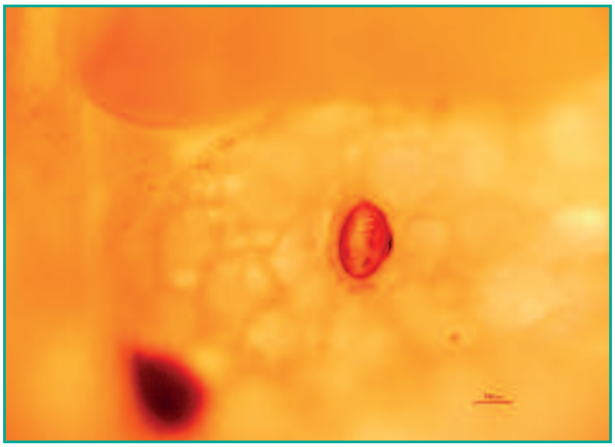

FIGURE 9: *Galleria mellonella, caterpillar, spiracle morphology.* Picture: Ahlfeld

FIGURE 11: *Bombyx mori, pupae; the cocoon has been removed.* Picture: Grabowski

FIGURE 12: *Crickets, from left to right: Acheta domesticus, Gryllus assimilis, Gryllus bimaculatus, nymphs and adults; the species may be differentiated by size and colour.* Picture: Grabowski

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FIGURE 13: *Locusts, from left to right: Schistocerca gregaria (adults above, nymphs below), Locusta migratoria (adults above, nymphs below); colours may vary because of heating (reddish). Size and head shape (seen from lateral) usually makes it easy to tell both species apart.*
Picture: Grabowski

FIGURE 14: *Gryllus bimaculatus, adults and nymph.*
Picture: Jansen

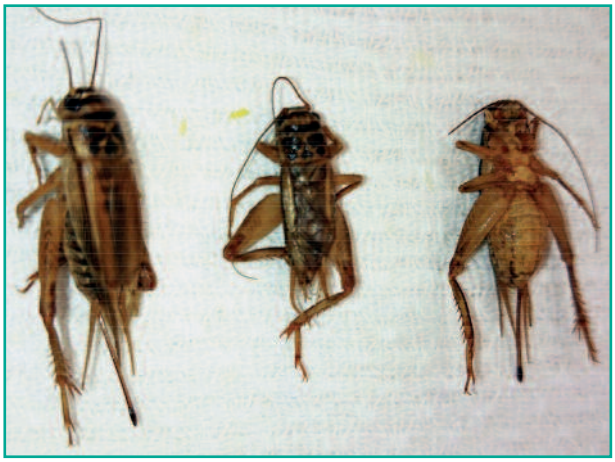

FIGURE 15: *Acheta domesticus, adults; note the two dark brown belts between eyes and antennae.*
Picture: Grabowski

the identification went down to the species and to the basic instar type; different larval stages etc. were not considered.

Most characteristics may be evaluated macroscopically. However, magnifying glasses are helpful, and two species may only be differentiated using a microscope (marked with ⊙). In the case of the waxworm caterpillars, a better appreciation of the spiracle morphology was obtained cutting the animal in half and observing only one half in the microscope (Fig. 9).

Preliminary key evaluation

A small-scale pilot study was performed to evaluate the key under real-life circumstances. In a lecture for students of veterinary medicine on edible insects, the key (in German) was distributed to the students, and they were asked to identify edible insects recently preserved in alcohol. An accompanying, voluntary questionnaire contained, for a maximum of five species, the following questions,

- Which species they identified,
- How they would rate, on a scale of 1 (very easy) to 6 (impossible), the easiness of the identification with the keys,
- What difficulties they encountered,
- What was particularly simple,
- What improvements of the key should be made, and
- Whether they would recommend this identification key.

Results and Discussion

In order to display the identification key with the modifications suggested by the students, the evaluation section is presented before the identification section.

Key evaluation

Eight students used the key to identify n = 20 insects. As they were free to choose the insect they would work with, the most popular (n = 3 each) were *Acheta (A.) domesticus, Galleria (G.) mellonella,* and *Zophobas (Z.) atratus* (also known as *Z. morio*). Regarding easiness, scores varied between 1 (very easy) to 3 (relatively easy), the mean being 1.85 ± 0.72. Ten difficulties were recorded, focusing on trouble to distinguish structures and colours (n = 7), to understand how a key works (n = 2), and to continue the identification because antennae were missing (n = 1).

A total of 15 comments were positive, stressing the systemic approach (n = 5), the general division into known basic types as crickets, locusts, larvae, and pupae (n = 4), easily recognisable features (n = 4), and the short time the identification takes (n = 1). One student just stated that it would be “very easy” without providing a reason.

Nine suggestions to improve the key were made, most of them (four) regarding a more manageable structure, keys to tell male from female animals (two), including sizes,

TABLE 2: *Identification key for edible insects that are commonly sold as foodstuff or feedstuff in Belgium, the Netherlands, and Germany (based on Friederich and Volland 1992; Schistocerca Information Site 2009[1]); Spilman 1991; Weisman 1991; modified). Keys marked with ⊙ refer to structures visible only microscopically.*

1	Insect is a larva of a holometabolous taxon, i. e., barely visible legs, elongated body typically unsegmented into head, thorax, and abdomen, exoskeleton soft or hard, *intra vitam* mobile; mealworms, grubs, caterpillars	2
	■ Insect is a pupa, i. e. undifferentiated extremities, typically barrel-shaped, *intra vitam* immobile; fly or butterfly pupae	9
	■ Insect is a larva resp. nymph of a hemimetabolous taxon or an imago, i. e. typically segmented into head, thorax and abdomen[2]) with marked extremities; crickets, locusts, beetles	10
2	Body relatively firm; mealworms (Fig. 1)	3
	■ Body relatively soft; grubs and caterpillars	6
3	Last abdominal segment ending in a small bifurcation. Up to 25 to 28 (exceptionally up to 34 mm) long and 2.5 to 3.5 mm thick. Muddy yellowish to corn yellow ➲ **(yellow) mealworm (*Tenebrio molitor;* Fig. 2)**	
	■ Last abdominal segment either blunt or pointed	4
4	Maximum length 13 mm and thickness 2 mm. Light brown with dark crossbands. *Intra vitam* quite quick	5
	■ Maximum length 5 cm and thickness 5 to 7 mm (thus the largest of the darkling beetles included here). Head and last three segments dark brown, a brown crossband on the hind margin of each other segment, and small brown dots on the middle segments. *Intra vitam* relatively slow ➲ **superworm (*Zophobas atratus [morio];* Fig. 3)**	
5	Margin of the lower part (sternite[3])) of the abdominal segments II to VII with three or more bristles. Upper part (tergite) of the last tail segment: the pair of bristles that is closest to the segment's tip does not reach beyond this tip ⊙ ➲ **lesser mealworm *Alphitobius diaperinus* (Fig. 4, 5)**	
	■ Margin of the lower part (sternite) of the abdominal segments II to VII with only two bristles. Upper part (tergite) of the last tail segment: the pair of bristles that is closest to the segment's tip reaches beyond this tip ⊙ ➲ **lesser mealworm *Alphitobius laevigatus***	
6	Grub, approx. 50 mm long and 10 mm thick, Muddy white with reddish-brown head and strong mouthpieces. Overlapping flanks ➲ **larvae of a sun beetle (*Pachnoda* spp.; Fig. 6)**	
	■ Elongated, with three regular, thoracal pairs of legs and thicker, so-called prolegs from the middle of the animal on towards its tail; butterfly caterpillars	7
7	Colour intense yellow, reddish or orange ➲ **tebo/butter worm (*Chilecomadia moorei;* Fig. 7)**	
	■ Colour pearly grey to silken black, with a spike on top of the 11th body segment ➲ **silk worm *(Bombyx mori)***	
	■ Colour yellowish. With a maximum length of 16 mm and thickness of 3 mm markedly smaller than the other two caterpillars; wax moth caterpillars	8
8	Four primitive eyes (stemmata) on the head. Lateral breathing openings (spiracles) yellow with a uniformly thick margin ⊙ ➲ **greater waxworm (*Galleria mellonella;* Fig. 8, 9)**	
	■ No eyes. Lateral breathing openings (spiracles) with a black margin, and the hind rim of this margin is thicker than the front rim ⊙ ➲ **lesser waxworm *(Achroia grisella)***	
9	Whitish-yellowish and showing similarities to adult beetles. Conspicuous bulgy segments ➲ **darkling beetle (*Tenebrionidae* spp.) pupa, i. e. *Tenebrio molitor, Zophobas atratus* or *Alphitobius* spp.**	
	■ Dark yellow, dark brown, grey or blackish. Front of the animal ending in a tip, its rear is blunter. Marked segmentation, hairs on every segment. Maximum length 27 mm ➲ **(pre)pupa of the black soldier fly, (*Hermetia illucens;* Fig. 10)**	
	■ Whitish, showing similarities to adult bees ➲ **honeybee pupa, bee brood *(Apis mellifera)***	
	■ Golden brown to reddish. Marked wings. Possibly covered by a whitish tissue resembling a tea bag (cocoon) ➲ **silk moth pupa (*Bombyx mori;* Fig. 11)**	
	■ Whitish, yellowish or brownish, may be covered by a cocoon ➲ **wax moth pupa *(Galleria mellonella, Achroia grisella)***	
	■ Orange to reddish, strong legs and wings, and if covered, then inside a capsule of substrate ➲ **sun beetle pupa (*Pachnoda* spp.)**	
10	First pair of wings hard-shelled (elytra[4])), short antennae. Colour black, dark brown or yellowish with reddish marks ➲ **beetle imago**	
	■ Two pairs of wings covered with small, powder-like scales ➲ **moth imago**	
	■ Two pairs of membranous wings, hairy thorax. Abdomen with dark crossbands ➲ **honeybee *(Apis mellifera)* imago**	
	■ The first pair of wings is well-developed, the second is turned to small bulbs (halters). A black fly resembling a wasp with transparent abdominal segments ➲ **black soldier fly imago *(Hermetia illucens)***	
	■ With or without wings, last pair of legs stronger and longer than the rest, usually spiny; locusts and crickets	11
11	Antennae as long as or longer than body; crickets (Fig. 12)	12
	■ Antennae markedly shorter than body; locusts (Fig. 13)	14

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12 Relatively large (up to 30 to 35 mm long and 12 to 15 mm thick), shiny black, solid wings (blackish brown in males, golden brown in females), two bright spots at the base of the wings ➲ **Mediterranean/two-spotted cricket (*Gryllus bimaculatus;* Fig. 14)**
- Basic colour brown 13

13 Light brown, mottled dark (dark back stripe on the back of nymphs). When seen from above: one dark brown stripe between eyes and another one between antennae. Maximum length 23 mm ➲ **house cricket (*Acheta domesticus;* Fig. 15)**
- Maximum length 27 mm and thickness 10 mm. Head light brown. When seen from above from thorax towards the head: conspicuous reddish brown, m-shaped mark between the eyes, abdomen black ➲ **(Jamaican) field cricket (*Gryllus assimilis;* Fig. 16)**
- Maximum length 22 mm and thickness approx. 6 mm. Light brown, lightly mottled, with three dark brown crossbands: one (slight) between the eyes, one on the hind rim of the upper side of the "neck" segment (pronotum), and one across the first abdominal segment (concealed by wings in the case of males). If winged, then wings short (even vestigial in females and nymphs, in males only the second pair of wings visible) Legs transparent ➲ **banded cricket *(Gryllodes sigillatus)***

14 When seen from the side, head rather oval. Up to approx. 4 to 6 cm long, light grey to light brown, darker spots ➲ **(African) migratory locust (*Locusta migratoria;* Fig. 17)**
- When seen from the side, head rather triangular 15

15 Maximum length 5 to 6 cm. Upper front portion of the "neck" segment (pronotum) with lateral dark brown stripes and with a medial yellowish stripe. Long, slender portion (tibia[5])) of the hind legs orange red. ➲ **American (desert) locust (*Schistocerca americana)***
- Maximum length 6 to 7 cm. Transverse notches (sulci) on the central ridge of the "neck" segment (pronotum). Long, slender portion (tibia) of the hind legs brownish. Nymphs green or yellow with black marks, imagines may be pinkish ➲ **desert locust (*Schistocerca gregaria;* Fig. 18)**

[1]) http://www.schistocerca.org/key.htm – [2]) Segments are grouped into major regions i. e. head, thorax, and abdomen. – [3]) Each segment is made of a dorsal (tergite), ventral (sternite), and lateral (pleurite) plate. In some taxons, segments have fused to form larger units. – [4]) In beetles, the first pair of wings was transformed to hard, protective cases for the second pair of wings. – [5]) Insect legs are made up by a series of elements, of which the muscular femurs and the slender tibiae are the largest ones.

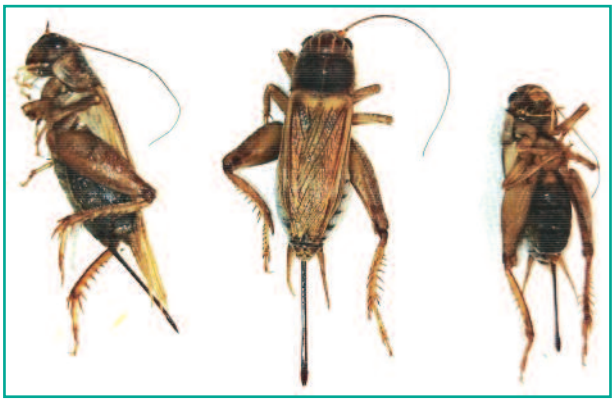

FIGURE 16: *Gryllus assimilis, adult; note the m-shaped field on the ventral side of the head.*
Picture: Grabowski

FIGURE 18: *Schistocerca gregaria, adults; note the somewhat more triangular shape of the head.*
Picture: Grabowski

FIGURE 17: *Locusta migratoria, adults; note the markedly round shape of the head and the colour pattern on the thorax.* Picture: Grabowski

images, and directions from which a given feature can be observed. All students would recommend this key; one stated that some species look very similar, requiring detailed keys.

Identification key

Table 2 contains the identification key including the observations the students made. Uncommon terms are briefly explained in footnotes. Most features can be appreciated macroscopically. However, some structures (e. g. bristles, spurs, spiracles) must be examined using magnifying glasses or even a microscope.

Another suggestion made by the students was being able to sex the insects. Sexing subadult insects is difficult and surpasses the needs of ordinary foodstuff inspection. Adult insects are, in some cases, easier to differentiate (Tab. 3.).

TABLE 3: *Sex differences of adult insects (Esquivel et al. 2012, Friederich and Volland 1992, Oliveira et al. 2015, Schoorl 1990).*

Insect species resp. group	item	Male	Female
Locusts	size	smaller	bigger
Crickets	ovipositor	absent	present
Wax moths, silk moth	abdomen size	thinner and shorter	thicker and longer
Chilecomadia moorei	antennae	shorter	longer
Tenebrio molitor	tibiae of front legs	curved	straight
Zophobas atratus	head width [mm]	4.5 to 5.0	3.5 to 4.0
Alphitobius spp.	2 distal, elongated spurs on the caudal rim of the tibiae of the middle legs	parallel, symmetrical	one is more curved than the other
Pachnoda spp.	lamellae on antennae	7	5
Apis mellifera	body and eye size	larger	smaller
Hermetia illucens	size	smaller	larger

The key (Tab. 2) contains many references to colours. However, they tend to fade when the animals are preserved in alcohol, as observed by the students (who worked with this kind of material). Live, raw, cooked, frozen or dried animals are more likely to keep their original colours.

Another point of criticism was lacking body parts, e. g. legs or antennae which inspection and evaluation is important to move on in the identification. This problem will arise with special specimens at all stages of production, increasing with the degree of processing. Especially drying will lead to broken-off appendages. In some cases, e. g. locusts, trimming of legs and wings may be intentional, but the identification key user will be able to tell the two genera *Locusta* and *Schistocerca* by the shape of the head and the colour.

Conclusion

So far, the amount of traded edible insects species is manageable. It is relatively easy to determine the main groups with the naked eye. Closely-related species and sex differentiation may be more challenging and will require magnifying glasses and a good light source. It is also advisable to build a small reference collection by preserving specimens in alcohol. However, unknown species are best submitted to experts.

Acknowledgements

The authors express their gratitude towards the students of veterinary medicine who evaluated the presented identification key.

Conflict of interest

The authors declare that they have no conflict of interest with regard to the present paper.

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