iSpot Bayesian keys:
The difference that makes a difference in biological identification

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Dichotomous keys

Identification of biological species is traditionally done by a paper-based dichotomous key:

- Q1 Does it have six legs?
  - Yes go to question 2
  - No go to question 8
- Q2 Does it have wings?
  - Yes …
  - No …

34a Abdomen globular and silvery (Fig. 49b). Tiny, adults never larger than 2 mm, femur I two to three times thicker than femur IV (best viewed from the side) (Fig. 49a) . . Family THERIDIOSOMATIDAE

Fig. 49a.

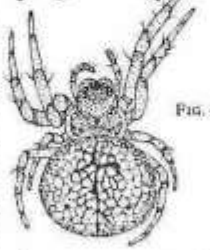


Fig. 49b.

THERIDIOSOMATIDAE

The only British species of this family is Theridiosoma gemmosum, *the Ray spider, named after the famous British naturalist John Ray. It is a tiny, globular spider with a distinctive silvery, patterned abdomen. The femora and tibia of the first leg are characteristically thickened and are between two and three times thicker than femur IV. The web is remarkable and sets the species apart from other orb weavers. The horizontal orb web is pulled into a taught conical shape by the spider who sits above the web at the end of a signal line attached to the centre* (Fig. 49c). *When a flying insect falls into the web it is released with a jerk, ensnaring the prey. In some ways this resembles the technique of the uloborid* Hyptiotes *(see p. 400). Mating is in the summer and the eggs are laid in a stalked sac hung in grassy vegetation. The life cycle is probably completed in a year and little is known of the mating ritual. The species is rare, being found low down in damp marshy vegetation. Length: 1.5–3 mm.*

(LM&M Vol II p. 168, as g. Theridiosoma*; Roberts Vol I p. 222, plt. 157)*

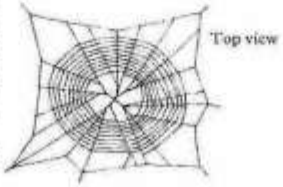
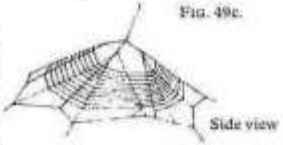


Fig. 49c.



34b If less than 2 mm in length and abdomen globular, then not silvery. If femur I thicker than femur IV then spider not less than 2 mm in length 35

Note: The following group of families may give the beginner some problems. Table 2 should provide some help if used with the key and glossary of terms.

35a When viewed from in front the clypeus is as high as or, more commonly, higher than the height of the median ocular area (Fig. 50) . . . . Family LINYPHIIDAE

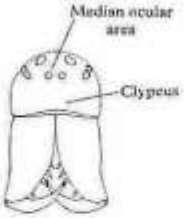


Fig. 50.

LINYPHIIDAE

Known as the money spiders, this family contains 267 species in 105 genera—approximately half of the British spider fauna. They are generally small spiders and the strong teeth on the fang furrows, the rebordered labium, the lack of a cheliceral boss and the wide clypeus help to distinguish them. They are quite variable in form and it is useful to consider the two subfamilies, the Erigoninae and the Linyphiinae, separately. Foreign workers consider the Erigoninae to be a separate family, the MICRYPHANTIDAE, and the Linyphiinae to constitute the family LINYPHIIDAE. In fact, the relationships within the group are difficult to resolve and it may be some time before workers in Britain accept a separation of the group into two families. The two subfamilies are keyed out on p. 418.

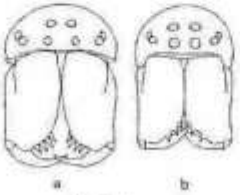


Fig. 51.

35b When viewed from in front the height of the clypeus less than the height of the median ocular area (Fig. 51a,b) . 36

36a Anterior median eyes when viewed from in front much larger than the remainder, five to six large teeth on the front margin of the cheliceral fang furrow (Fig. 52) . . . . . Family LINYPHIIDAE

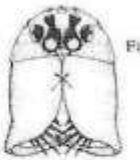


Fig. 52.

A single species, *Tapinopa longidens*, keys out here. It is the only linyphiid, of over 250 species, to have a narrow clypeus. A full family description is given in couplet 35a, above.

36b Eyes all the same size and shape, teeth on the front margin of the cheliceral fang furrow (not as above) 37

37a Head region contrastingly dark against pale thoracic region (Fig. 53a); orb web with a section missing (Fig. 53b) Family METIDAE

Fig. 53a.

Three species of the genus *Zygiella* key out here. They are very like the araneids in appearance but are considered to fall within the Metidae. A full description of the family is given in couplet 33b, above.

37b Head region not contrastingly dark against pale thoracic region; orb web complete (Fig. 54a) . . . . . Family ARANEIDAE

Fig. 53b.

ARANEIDAE

Orb-weavers, containing 33 species in 15 genera. Adults have a large, patterned, globular abdomen that considerably overhangs the cephalothorax (Fig. 54b). *The legs are often heavily spined, the maxillae are shorter than, or as long as, broad* (Fig. 54c). *There is a protrusion on the side of each chelicera called a boss* (Fig. 54d). *Flying insects are snared in their orb webs, wrapped with silk and eaten. Mating involves a complex series of vibration and jerking of the female's web by the male, who may mate with several females during the summer. Each time he risks loosing legs or palps until, finally, he cannot escape and at the last time of mating is devoured. Eggs are laid following mating and some of the larger species may take two or three years to reach maturity and complete their life cycle. The webs are found in a variety of habitats: spun horizontally in short grass in* Hyposinga*; in long grass, heather, scrub and woodland in a variety of species; or in the eaves of buildings and across farm gates as in* Nuctenea umbratica. *This family includes the garden spider* Araneus diadematus. *Length: 3–15 mm.*

(LM&M Vol II p. 111, Vol III p. 64; Roberts Vol I p. 205, plts. 136–156)

Fig. 54a.

Fig. 54b.

Fig. 54c.

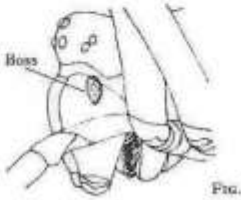


Fig. 54d.

37b Head region not contrastingly dark against pale thoracic region; orb web complete (Fig. 54a) . . . . . .
Family ARANEIDAE

FIG. 53a.

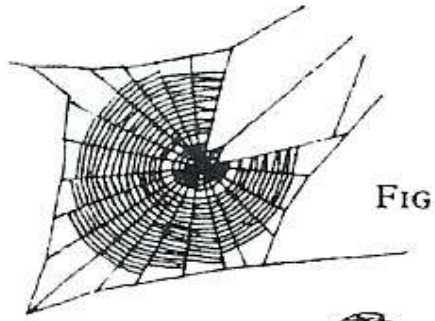


FIG. 53b.

ARANEIDAE

Orb-weavers, containing 33 species in 15 genera. Adults have a large, patterned, globular abdomen that considerably overhangs the cephalothorax (Fig. 54b). *The legs are often heavily spined, the maxillae are shorter than, or as long as, broad* (Fig. 54c). *There is a protrusion on the side of each chelicera called a boss* (Fig. 54d). *Flying insects are snared in their orb webs, wrapped with silk and eaten. Mating involves a complex series of vibration and jerking of the female's web by the male, who may mate with several females during the summer. Each time he risks loosing legs or palps until, finally, he cannot escape and at the last time of mating is devoured. Eggs are laid following mating and some of the larger species may take two or three years to reach maturity and complete their life cycle. The webs are found in a variety of habitats: spun horizontally in short grass in* Hyposinga*; in long grass, heather, scrub and woodland in a variety of species; or in the eaves of buildings and across farm gates as in* Nuctenea umbratica. *This family includes the garden spider* Aranaeus diadematus. *Length: 3–15 mm.*

(LM&M Vol II p. 111, Vol III p. 64; Roberts Vol I p. 205, plts. 136–156)

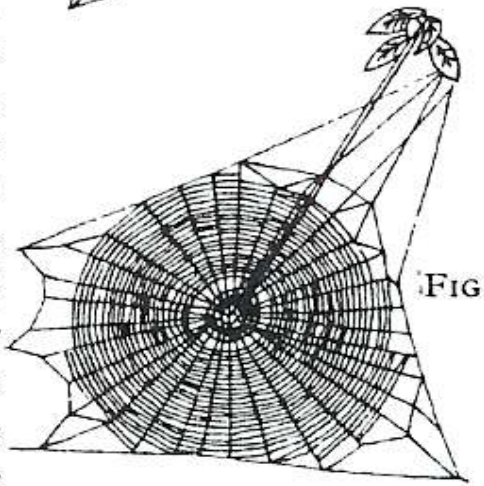


FIG. 54a.

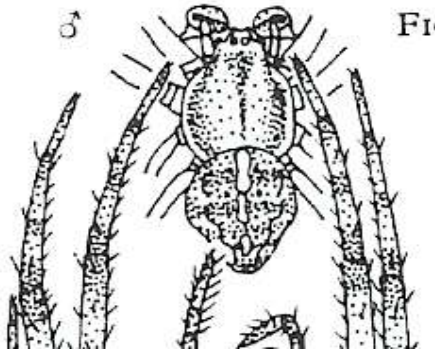


FIG. 54b.

Problems with dichotomous keys

- Cumbersome
- Error-prone
- Don’t match ‘natural’ strategies:
  - note distinctive characters
  - relate unknown to known species
  - make a tentative identification and then check

Computer-aided methods

- Techniques:
  - Interactive branching keys
  - Multi-access keys
  - Bayesian statistics
  - Other:
    - Numerical taxonomy
    - Image recognition
    - DNA barcoding…
- Promise:
  - Easy to use
  - Support user strategies
  - Quicker and more robust identification

Species × character data matrix

Species x character data matrix:

Character	Legs					Wings			Shell		Segmented bo			Waist		Wing case			Mouthparts	
State	none	six	eight	twelve-fourteen	many	none	one pair	two pairs	no shell	chalky shell	non-segmented	few segments	many segments	yes	no	no wing case	soft or partial wing ca	hard wing case	biting, chewing and ot	piercing and sucking r
Spider			x			x			x			x		x		x			x	
Harvestman			x			x			x			x			x	x			x	
Woodlouse				x		x			x			x			x	x			x	
Centipede					x	x			x				x		x	x			x	
Millipede					x	x			x				x		x	x			x	
Slug	x					x			x		x				x	x			x	
Snail	x					x				x	x				x	x			x	
Insect larva (eg fly grub)	x					x			x			x			x	x			x	
Insect larva (eg aphid nymph)		x				x			x			x			x	x			x	
Worm	x					x			x				x		x	x			x	
Fly		x					x		x			x			x	x			x	
Bee or Wasp		x						x	x			x		x		x			x	
Ant		x				x			x			x		x		x			x	
Butterfly or Moth		x						x	x			x			x	x			x	
Beetle		x					x		x			x			x			x	x	
Grasshopper		x					x		x			x			x		x		x	
Bug		x					x		x			x			x		x			x

Bayesian approach

$$P(S_i \mid C) = \frac{P(C \mid S_i)P(S_i)}{\sum_j P(C \mid S_j)P(S_j)}$$

$P(S_i)$ prior probability of species *i*

$P(S_i|C)$ prob. of species *i* given character C

$P(C|S_i)$ prob. of character C given species *i*

By default, ‘present’ ≡ 0.9, ‘absent’ ≡ 0.1

Bayesian approach

- Species are ranked in order of likelihood
  - Prior probability can be set by distribution records
- As specimen described:
  - Increase likelihood for species showing character state
  - Decrease likelihood for species not showing character state
- Species never excluded
  - Robust to occasional mistakes

Shannon information

- Characters are offered in rank order
  - Ranked by discriminating power using Shannon index
  - Reordered as identification proceeds
- Can be reordered for diagnostic characters
  - Most discriminating for ‘hunch’ species
- Suggested order can always be ignored
  - Characters that are missing, difficult,…

Shannon information

$$H' = -\sum_k p_k \ln p_k$$

p_k probability of character state k

p_k is conditional on current species probabilities

H' is treated as figure of merit to order characters

Demo

- Live server
  - www.ispot.org.uk/webkeys
  - www.ispot.org.uk/mobilekeys
- PowerPoint demo
  - Mobiles
- Developing new keys

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Steve's Wildlife: http://www.flickr.com/photos/steveinleighton/4973564544/

How to use a key

View characters | View species | Compare species | Diagnostic characters

Characters available

- **Colour**
- Eye
- Lungs
- Antennal flagellum
- Surface
- Outline shape
- Habitat
- Pattern

Colour?

- white
- pink
- buff
- brown
- grey

Select

Species (most likely first)

http://www.ispot.org.uk/node/5489

- Common pill woodlouse ✓✓
- Common rough woodlouse
- Common shiny woodlouse
- Common sea slater
- Armadillidium depressum
- Armadillidium nasatum
- Cylisticus convexus
- Porcellio dilatatus
- Porcellio laevis
- Trachelipus rathkei
- Armadillidium pictum

Characters used

- Maximum length: large (more than 15mm)
- Behaviour when disturbed: rolls into perfect ball

Change | Delete

Pick characters to describe your specimen

Most likely species ticked

Characters used so far

Click any species to see a full description

Change your mind

Set your location

Click on the map to add a marker to show where your specimen was found then click Set location

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Check a description

View characters | View species | Compare species | Diagnostic characters

Common pill woodlouse *(Armadillidium vulgare)* ✓✓

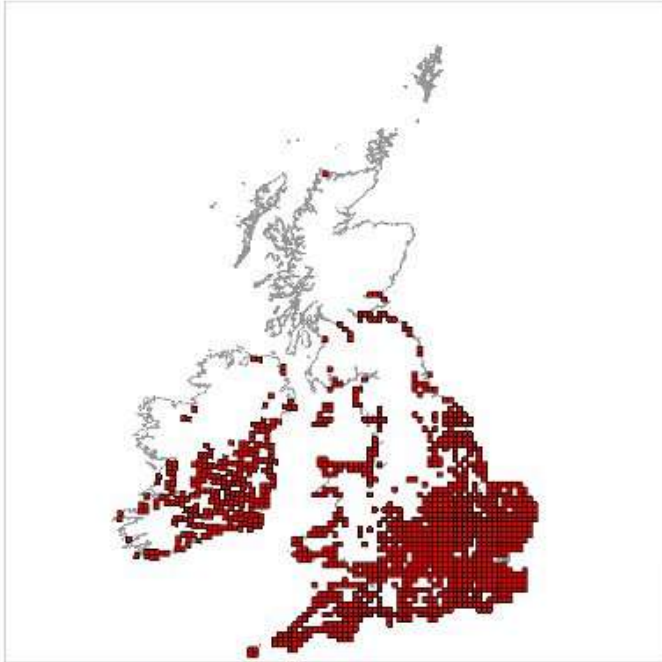
Very common. Able to roll into complete ball. Colour normally uniform slate-grey.

http://www.ispot.org.uk/node/5489

http://www.ispot.org.uk/node/5489

- Antennal flagellum: two distinct sections
- Behaviour when disturbed: **rolls into perfect ball**
- Colour: pink; brown; grey
- Eye: 3 lenses
- Habitat: wide range of natural and man-made sites
- Lungs: two pairs
- Maximum length: **large (more than 15mm)**
- Pattern: uniform
- Surface: smooth

Distribution map for Common pill woodlouse (*Armadillidium vulgare*)



Powered by NBN Gateway terms and conditions

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Compare two species

View characters | View species | Compare species | Diagnostic characters

Species	Common pill woodlouse ✓✓ *(Armadillidium vulgare)*	Common rough woodlouse *(Porcellio scaber)*
	 http://www.ispot.org.uk/node/5489	 http://www.ispot.org.uk/node/3336

Characters		
Antennal flagellum:	two distinct sections	two distinct sections
Behaviour when disturbed:	**rolls into perfect ball**	*initially motionless; may move rapidly*
Colour:	pink; brown; grey	grey
Eye:	3 lenses	numerous lenses
Habitat:	wide range of natural and man-made sites	wide range of natural and man-made sites
Lungs:	two pairs	two pairs
Maximum length:	**large (more than 15mm)**	**large (more than 15mm)**
Outline shape:	Not known	no step in outline
Pattern:	uniform	uniform
Surface:	smooth	bumps
Description	Very common. Able to roll into complete ball. Colour normally uniform slate-grey.	Very common. Usually slate-grey, but occasinally orange/cream speckled with brown/black. Rough surface

Find diagnostic characters

View characters | View species | Compare species | Diagnostic characters

Diagnostic characters of Common pill woodlouse ✓✓ (most important listed first)

1. Behaviour when disturbed : **rolls into perfect ball**
2. Eye : 3 lenses
3. Maximum length : **large (more than 15mm)**
4. Lungs : two pairs
5. Antennal flagellum : two distinct sections
6. Colour : pink; brown; grey
7. Habitat : wide range of natural and man-made sites
8. Surface : smooth
9. Pattern : uniform
10. Outline shape : Not known

http://www.ispot.org.uk/node/5489

To use this character ordering in the identification Click here

Use your mobile

http://www.iSpot.org.uk/mobilekeys

phones with large touch screen

phones with small screen and cursor

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Developing new keys

Login to develop a Bayesian key

Username: J.P.Rosewell@open.ac

Password: ••••••••

Login Reset

If you have forgotten your password click here to generate a new one.

Developing new keys

Create web keys | Create mobile-web keys | Delete web keys | Delete mobile-web keys | Key tools

Change password | Sign out

Creating new web keys

Key file (CSV or Excel 95 to 2003): Browse...

Zip file of local images and descriptions: Browse...

Glossary file (CSV or Excel 95 to 2003): Browse...

Submit Reset

Learn how to build keys

- Download a tutorial on building keys from here.
- The templates used to develop keys are here.
- The examples used in the tutorial are here.

Installed web keys

- Common British earthworms -- DRAFT (v. 1.9.4)
- Crustose lichens on trees -- DRAFT (v. 0.15)
- Dragonflies and Damselflies (v. 1.2)
- Earthworms (v. 0.3)
- Families of water beetles (v. 0.1)
- Families of water beetles (v. 0.2)
- Foliose lichens on trees -- DRAFT (v. 0.15)
- Freshwater minibeasts (v. 0.4)
- Fruticose lichens on trees -- DRAFT (v. 0.15)
- Ladybirds (v. 0.4)

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Developing new keys

Species x character data matrix

Character	Maximum length				Colour					Pattern			Surface			Eye				Lungs			Antennal flagellum				Outline s		Behaviour when di			
State	very small (less than 5mm)	small (5-10mm)	medium (10-15mm)	large (more than 15mm)	white	pink	buff	brown	grey	uniform	mottled	stripes or rows of patches along	smooth	ridged	bumps	blind	1 lens	3 lenses	numerous lenses	none	two pairs	five pairs	one tapering section	two distinct sections	three distinct sections	ten or more distinct sections	no step in outline	step towards rear	initially motionless; may move	walks slowly	runs rapidly	curls but not into complete ball
Rosy woodlouse		x				x						x			x		x			x			x					x			x	
Armadillidium album		x					x						x						x		x			x								x
Armadillidium depressum				x					x	x			x						x		x			x								x
Armadillidium nasatum				x				x	x			x	x						x		x			x								x
Armadillidium pictum		x							x		x		x						x		x			x								
Armadillidium pulchellum		x						x			x		x						x		x			x								x
Common pill woodlouse				x		+		+	x	x			x					x			x			x								
Buddelundiella cataractae	x				x		x							x					x	x			x									
Cylisticus convexus				x				x	+	x			x				x					x		x			x				x	x
Eluma purpurascens			x					x		x							x			x				x								x
Halophiloscia couchi			x			x		x			+		x						x	x					x			x			x	
Haplophthalmus danicus	x				x					x				x			x			x			x							x		
Haplophthalmus mengei	x				x					x				x			x			x			x							x		
Haplophthalmus montivagus	x				x					x				x			x			x			x							x		
Common sea slater				x			x		x	x					x				x	x						x	x				x	
Ligidium hypnorum		x						x			x		x						x	x						x		x			x	
Metatrichoniscoides celticus	x				x					x					x	x				x			x					x		x		
Metatrichoniscoides leydigi	x				x					x					x	x				x			x					x		x		
Miktoniscus patiencei	x				x					x					x		x			x			x				x			x		
Common shiny woodlouse				x					x	x			x						x	x					x		x		x			
Oritoniscus flavus		x						x		+	+		x				x			x			x					x			x	
Common striped woodlouse			x					x			x	x	x						x	x					x			x			x	

Developing new keys

```
<character id="margins">
  <charName>margins</charName>
  <question>Do the margins bear eyelash-like whiskers (<glossary ref="g_cilia" text="cilia"/>)?</question>
  <description><p><img src="cilia-Physcia leptalea.jpg" /></p></description>
  <state id="margins_cilia">
    <stateLabel>whiskers round the margins</stateLabel>
    <image>cilia.gif</image>
        <shownBy ref="Parmotr_perl" />
        <shownBy ref="Physcia_adsc" />
        <shownBy ref="Physcia_tene" />
        <shownBy ref="Physcia_leptalea" />
  </state>
  <state id="margins_plain">
    <stateLabel>margins without whiskers</stateLabel>
        <shownBy ref="Physcon_dist" />
        <shownBy ref="Physcon_ente" />
        <shownBy ref="Melan_subaur" />
        <shownBy ref="Melan_fulig" />
        <shownBy ref="Melanohalea_laci" />
        <shownBy ref="Melanohalea_exasperata" />
        <shownBy ref="Candelaria_conc" />
        <shownBy ref="Xanthoria_pari" />
        <shownBy ref="Xanthoria_poly" />
        <shownBy ref="Hypogy_phys" />
        <shownBy ref="Hypotr_revo" />
        <shownBy ref="Phaeoph_orbi" />
        <shownBy ref="Flavoparm_cape" />
```

Developing new keys

View characters | View species | Compare species | Diagnostic characters

Characters available

- **Colour**
- Eye
- Lungs
- Antennal flagellum
- Surface
- Outline shape
- Habitat
- Pattern

Characters used

○ Maximum length: large (more than 15mm)

○ Behaviour when disturbed: rolls into perfect ball

Change | Delete

Colour?

- ○ white
- ○ pink
- ○ buff
- ○ brown
- ○ grey

Select

Species (most likely first)

http://www.ispot.org.uk/node/5489

- Common pill woodlouse ✓✓
- Common rough woodlouse
- Common shiny woodlouse
- Common sea slater
- Armadillidium depressum
- Armadillidium nasatum
- Cylisticus convexus
- Porcellio dilatatus
- Porcellio laevis
- Trachelipus rathkei
- Armadillidium pictum

Contacts

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J.P.Rosewell@open.ac.uk

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iSpot keys

Use your computer or mobile to help you identify wildlife.

iSpot keys are new and easy to use.
They suggest the species in your area that best match what you have found.

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Keys

- Visit iSpot:
  - http://www.iSpot.org.uk
- Follow link to keys
  - http://www.iSpot.org.uk/webkeys
  - http://www.iSpot.org.uk/mobilekeys
- Use the help page to get started

Current keys

Select an identification key

Keys for beginners

Earthworms (v. 0.3)

A simplified key to common British earthworms, based on data provided by David Jones, Natural History Mus

Freshwater minibeasts (v. 0.4)

A basic key to major groups of invertebrates found in freshwater, based on material from the Open Universi

Ladybirds (v. 1.1)

A key to British ladybirds

Minibeasts (v. 0.15)

A basic key to major groups of invertebrates found in gardens and similar habitats

Keys for users with some experience

Dragonflies and Damselflies (v. 1.2)

A key to most of the species of dragonflies and damselflies found in the month of May in the British Isles.

Families of water beetles (v. 0.2)

A key to families of water beetles

Woodlice (v. 0.5)

A key to all woodlice species in Britain and Ireland

Keys for experts

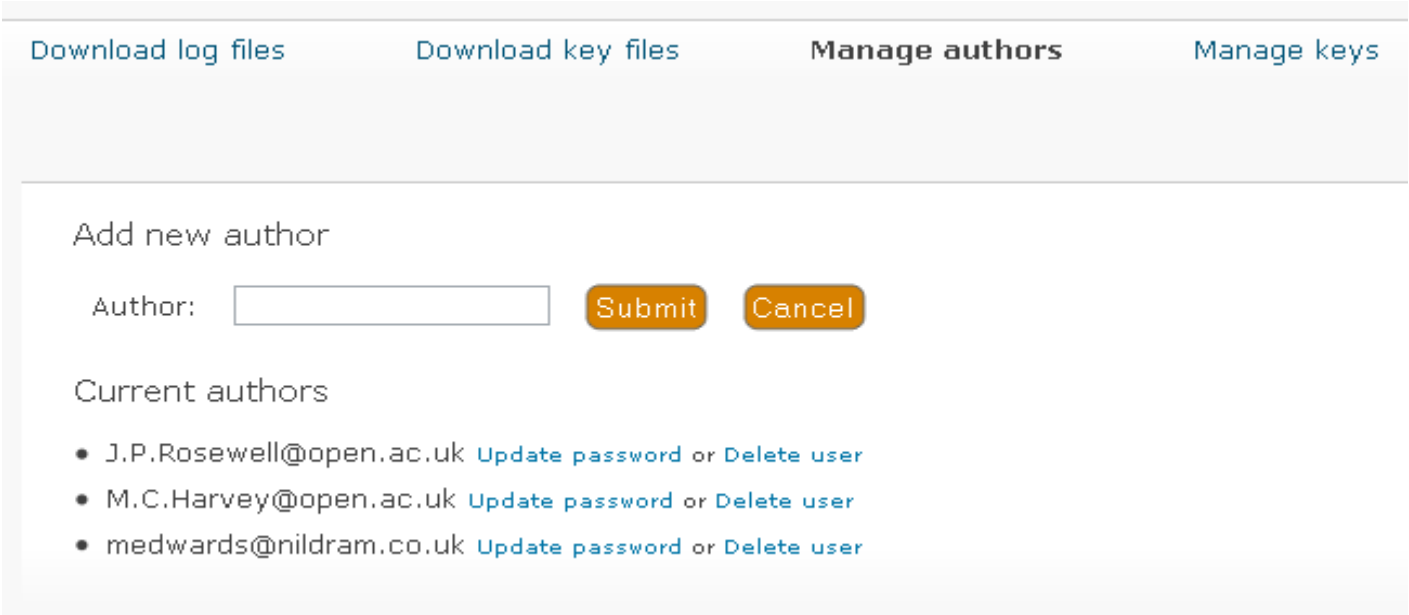
Common British earthworms -- DRAFT (v. 1.9.4)

A key to the 12 common species of British earthworms included in the Opal earthworms survey.

Crustose lichens on trees -- DRAFT (v. 0.15)

A key to some crustose lichens on trees in England, created for OPAL air quality survey.

Any volunteers?



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LOTTERY FUNDED

A simple key in Excel

Microsoft Excel - aquaticmini.0.1.csv

	A	B	C	D	E	F	G	H	I
1	Title	Freshwater minibeasts							
2	Species x character data matrix:								
3		Shell	Segement	Jointed lim	Other appe	Pairs of lim	Wings	Live in a ca	Tails'
4	Mollusc (snail, bivalve, limpet)	yes	no	no		none	no	no	none
5	Flatworm	no	no	no		none	no	no	none
6	Fly larva (midge, mosquito, cranefly, bl	no	yes	no	yes	none	no	no	none
7	'Worm' (true worm, leech)	no	yes	no	no	none	no	no	none
8	Beetle (adult), water bug	no	yes	yes		three	yes	no	none
9	Cased caddis fly larva	no	yes	yes		three	no	yes	none
10	Mayfly nymph, damslfly nymph, dragor	no	yes	yes		three	no	no	three
11	Stonefly nymph, caseless caddis fly ar	no	yes	yes		three	no	no	two
12	Alderfly larvae, some beetle larvae	no	yes	yes		three	no	no	one
13	Arachnid (spider, mite)	no	yes	yes		more than	no	no	none
14	Crustacean (shrimp, water hoglouse)	no	yes	yes		more than	no	no	none

Species × character data matrix

Species x character data matrix																																
Character	Maximum length				Colour					Pattern			Surface			Eye				Lungs			Antennal flagellum				Outline s		Behaviour when di			
State	very small (less than 5mm)	small (5-10mm)	medium (10-15mm)	large (more than 15mm)	white	pink	buff	brown	grey	uniform	mottled	stripes or rows of patches along	smooth	ridged	bumps	blind	1 lens	3 lenses	numerous lenses	none	two pairs	five pairs	one tapering section	two distinct sections	three distinct sections	ten or more distinct sections	no step in outline	step towards rear	initially motionless; may move	walks slowly	runs rapidly	curls but not into complete ball
Rosy woodlouse		x				x						x			x		x			x			x					x			x	
Armadillidium album		x					x						x						x		x			x								x
Armadillidium depressum				x					x	x			x						x		x			x								x
Armadillidium nasatum				x				x	x			x	x						x		x			x								x
Armadillidium pictum		x							x		x		x						x		x			x								
Armadillidium pulchellum		x						x			x		x						x		x			x								x
Common pill woodlouse				x		+		+	x	x			x					x			x			x								
Buddelundiella cataractae	x				x		x							x					x	x			x									
Cylisticus convexus				x				x	+	x			x				x					x		x			x				x	x
Eluma purpurascens			x					x		x							x			x				x								x
Halophiloscia couchi			x			x		x			+		x						x	x					x			x			x	
Haplophthalmus danicus	x				x					x				x			x			x			x							x		
Haplophthalmus mengei	x				x					x				x			x			x			x							x		
Haplophthalmus montivagus	x				x					x				x			x			x			x							x		
Common sea slater				x			x		x	x					x				x	x						x	x				x	
Ligidium hypnorum		x						x			x		x						x	x						x		x			x	
Metatrichoniscoides celticus	x				x					x					x	x				x			x					x		x		
Metatrichoniscoides leydigi	x				x					x					x	x				x			x					x		x		
Miktoniscus patiencei	x				x					x					x		x			x			x				x			x		
Common shiny woodlouse				x					x	x			x						x	x					x		x		x			
Oritoniscus flavus		x						x		+	+		x				x			x			x					x			x	
Common striped woodlouse			x					x			x	x	x						x	x					x			x			x	