THE DUTCH SPECIES OF *LIMNESIA*, WITH ECOLOGICAL AND BIOLOGICAL NOTES (ACARI: HYDRACHNIDIA: LIMNESIIDAE)

Ton van Haaren & David Tempelman

This paper treats nine water mite species of *Limnesia* now known to occur in the Netherlands. Two species are new for the Netherlands: *L. marmorata* and *L. curvipalpis*. *Limnesia angustata*, previously considered a variety of *L. maculata* and raised to species level later on in the 20th century, fits the original description of *L. marmorata* and is similar to the type material of *L. marmorata*. Therefore *L.angustata* is synonymised with *L. marmorata*. A key to the nine species of the Netherlands is given as well as an overview of the ecology and, where available, information on the biology. *Limnesia marmorata* is very common, occurring in ditches, lakes and rivers, whereas *L. curvipalpis* is rare, being found in moorland pools and a eutrophic canal. With both latest additions, the Dutch list of water mite species now numbers 248.

INTRODUCTION

Water mites can be used as indicator species for the biological quality of water. This value is recognised within the framework of the European Water Quality Guideline (Van der Molen & Pot 2007) and it has boosted research on macro-invertebrates. To investigate whether 28 'water bodies' in the Amsterdam-Utrecht region meet the required biological quality according to this Guideline, over 200 macro-invertebrate samples were analysed (Tempelman 2007).

The area of study is famous for its shallow lakes, of which lake Naardermeer, a natural lake, is the most famous. However, also many other lakes here, which originated as a consequence of peat excavations in past centuries, have a high natural value. Many water mite species occur in these habitats, including many rare ones.
When identifying the water mites of these lakes, it became apparent that within the material of *Limnesia maculata* (Müller, 1776) two forms were present, clearly differing in colour and size. Also,

Species	Parasitic larvae
L. connata Koenike, 1895	No
L. curvipalpis Tuzovskij, 1997	Unknown
L. fulgida Koch, 1836	Yes (host: aquatic Coleoptera (?), Chironomidae and Sphaeroceridae)
L. maculata (O.F. Müller, 1776)	Yes (host: Chironomidae: Chironomini)
L. marmorata Neuman, 1870	No
L. koenikei Piersig, 1894	Unknown
L. polonica Schechtel, 1910	Unknown
L. undulata (O.F. Müller, 1776)	No
L. undulatoides Davids, 1997	Yes (host unknown)

Table 1. The Dutch species of *Limnesia* and overview of parasitism.
Tabel 1. De Nederlandse *Limnesia*-soorten en een overzicht van hun parasitisme.

IN SEARCH OF THE CORRECT NAME OF *LIMNESIA MARMORATA*

Limnesia maculata was described in 1776 by O.F. Müller as *Hydrachna maculata*. His description, in a paragraph on four-eyed mites, was very brief: '*Hydrachna maculata* is red, egg-shaped, with black dorsal markings. She variates by the number of markings, and by long and short palps' (fig. 1). Apart from *L. maculata*, this description might match several other (*Limnesia*-) species. However we did not study type material to verify which species actually was involved in the original description.

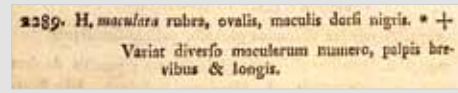

2289. H. *macularo rubra, ovalis, maculis dorsi nigris.* * +
Variat diverso macularum numero, palpis brevibus & longis.

Figure 1. The original description of *Hydrachna maculata*. Source: Müller (1776).
Figuur 1. De oorspronkelijke beschrijving van *Hydrachna maculata*. Bron: Müller (1776).

In 1837, C.L. Koch gives more elaborate descriptions of the *Limnesia* species. However, he mainly concentrates on the colour of dorsal side and legs, and in a section on '*L. maculata*' he writes: 'pedipalps and legs ochre yellow with olive green striping'. This hardly fits the current concept of *L. maculata*. As morphological features lack from his plethora of described *Limnesia*-species, his contribution to the *Limnesia*-taxonomy is hardly useful.

C.J. Neuman (1870) describes *L. marmorata*. In 1880, he gives an additional description: 'Body of similar form as the preceding species [*L. pardina* = *L. undulata*], but less high, with dark spots, which are marked with white and rose-red lines. Legs longish, greyish, with hairs as in preceding species. Palps shorter, as in *L. maculata*, but much more slender than the first pairs of legs; the second segment with a small buckle, which is conical in shape, and is directed outwardly, hardly [directed] in backward direction, whilst its style however is directed in backward direction. Length 2-2.3 mm' (translated from Latin description in Neuman, 1880). In his more comprehensive description he adds that the genital field exhibits, in the female, more of an oval than rectangular shape, the outer contour being weakly convex. In our opinion this, and his more comprehensive, description fits the current concept of *L. marmorata* (see also fig. 2).

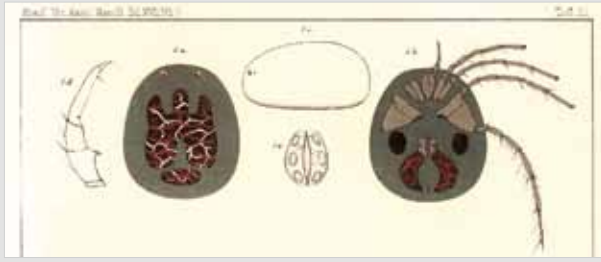


Figure 2. The earliest picture of *Limnesia marmorata*, in Neuman 1880 (table XII, fig. 1).
Figuur 2. De eerste tekening van *Limnesia marmorata*, in Neuman (1880, tabel XII, fig. 1).

Unfortunately, from this point on, the taxonomical literature strays into two directions. In western literature, *L. marmorata* is considered a form, variety or subspecies of *L. maculata*, although several authors realise both entities occur in different habitats (Lundblad 1912, 1962, Viets 1936, Dresscher 1954). Russian literature follows a different track. Sokolow (1930) is unaware of Neuman's '*L. marmorata*' and describes a variety of *L. maculata*, naming it *angustata*. Wainstein (1977) gives an account of the morphology and biology of the two forms. Neglecting Lundblad's 1962 synonymy of *L. marmorata* with *L. maculata*, he concludes that *L. angustata* is a separate species. This is followed by Tuzovskij (1997), who gives a thorough revision of the entire genus. However, Tuzovskij did not refer to all relevant literature, for instance missing Neuman's '*marmorata*'. As Neuman's description of *L. marmorata* and his type material from Lake Mälaren fits the smaller, yellow 'form' of *L. maculata*, *L. angustata* is to be synonymized, making *L. marmorata* the correct name (see paragraph on Synonymy).

Figure 3. *Limnesia undulata* nymph, ventral view. Photos Ton van Haaren, unless otherwise mentioned.
Figuur 3. *Limnesia undulata* nimf, ventraal aanzicht. Foto's Ton van Haaren, tenzij anders vermeld.

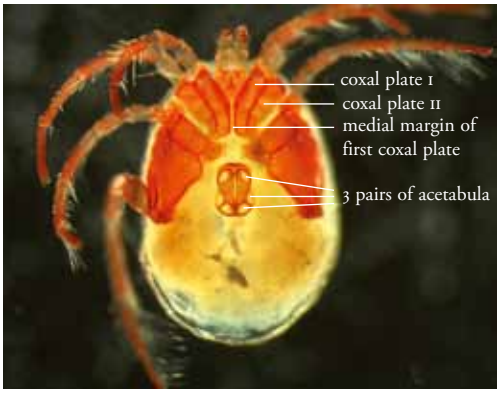


Figure 4. *Limnesia maculata* adult female, ventral view.
Figuur 4. *Limnesia maculata* adult vrouwtje, ventraal aanzicht.

the genital structures differed, especially in the females. Could two species be involved? A literature search showed that this was actually the case: both *Limnesia maculata*, which is red and large and *L. marmorata* Neuman, 1870, which is small and yellow were present and both were equally common. A literature search revealed that *L. angustata* (Sokolow, 1930) refers to the same species and it is synonomized here with *L. marmorata*.

Further study of *Limnesia* revealed that also *L. curvipalpis* Tuzovskij, 1997 occurs in the Netherlands. This recently described species was also lacking from keys used in western Europe. As both *L. marmorata* and *L. curvipalpis* are new to the Dutch fauna, the total number of Dutch *Limnesia* species rises from seven to nine (table 1).

PARASITISM AND SIBLING SPECIES

From an evolutionary point of view, *Limnesia* is an interesting genus of water mites. Within the genus, several sibling species occur. These sibling pairs show strikingly different life cycles: one species has a parasitical life cycle, the sibling being non-parasitic. This loss of parasitism is a divergence which probably is a relatively recent phenomenon (Smith 1998). In the case of *L. maculata* and *L. marmorata*, *L. maculata* is parasitical, the latter species is not. This difference in life cycle also has morphological ramifications for the larvae: *L. maculata* has a smaller body (dorsal shield) than the larvae of *L. marmorata*, but has longer legs than its sibling species (see under *L. maculata*, biology).

Another sibling pair is *undulata - undulatoides.* They show the same biological difference as *maculata - marmorata*. Perhaps, more sibling pairs may emerge. Table 1 gives an overview of the known parasitism of our *Limnesia* species.

KEY TO THE SPECIES

Male genital valves are curved, the anterior and posterior areas of both plates approximating, touching or even interconnected in some species. Due to these decurvations, the central area of the genital field is left open (fig. 5). In females, the plates are curved less, having straight medial margins that nearly touch, leaving no open space in the central area. Although they are closely together, the plates lie free and are not interconnected. Furthermore, the females have a

sickle-shaped chitinous patch, called the pregenital sclerite (the 'Vaginalstützkörper' in Viets, 1936) in front of the genital plates, which is lacking in males (fig. 14).

1. Genital plates with two pairs of acetabulae (fig. 3). PII always without pedestal or spine . . . . . nymphs
- Genital plates with three pairs of acetabulae (fig. 4). PII always with an accessory pedestal and/or spine/style . . . . . adults (2)
2. First coxal plates interconnected with small arched bridge (fig. 34). Medial distance between first coxal plates about as large as width of first epimeral plate 7
- First coxal plates neither fused nor interconnected with small arched bridge, (almost) touching medially (fig. 4) 3
3. Ventral margin of PII without pedestal but with very short medial spine (fig. 23). Very small species, body length < 0.8 mm . . . . . *L. connata*
- Ventral margin of PII concave or with pedestal (conical or cylindrical) (fig. 24-27). Larger species, body length usually > 0.8 mm 4
4. Ventral margin of PII distally widened, thicker than proximal part of PIII, without pedestal but only with long distal style (fig. 24). Genital valves in males widened and angular in the middle (fig. 8) . . . . *L. koenikei*
- Ventral margin of PII with small distal or medial pedestal and short spine (fig. 25-27). Male genital valves rounded (fig. 12) . . 5
5. Ventral margin of PII with short medial pedestal and spine (fig. 27). First coxal plates with medial sclerotised extension, their medial margin over short distance close to each other (fig. 33). Male genital plates with numerous hairs only along the edges (fig. 7) . . . . . *L. fulgida*
- Ventral margin of PII with short distal pedestal and spine (fig. 25-26). First coxal plates running parallel over nearly half of their length (fig. 32). Hairs on male genital plates not restricted to edges but on the entire surface (fig. 9, 10) 6
6. Chitinous parts usually red. Acetabula large, distance between anterior and central acetabula in both sexes at most length of central acetabula (fig. 9, 18). Larger species: length of IV-leg-5 ≥ 370 µm (see also table 3). III-leg-4 and 5 with 10-14 swimming hairs each . . . . . *L. maculata*
- Chitinous parts sand-coloured, grey or various gradations of sky blue. Genital plate in females oblong, its length considerably longer than its width (fig. 19). Distance between anterior and central acetabula in females at least 1.5× the length of central acetabula. Smaller species: length of IV-leg-5 ≤ 320 µm (exceptionally up to 360 µm) (see also table 3). III-leg-4 and -5 with 5-9 swimming hairs each . . . . . *L. marmorata*
7. Pedestal on ventral margin of PII equally long as distal spine and about as long as wide. PIV with slightly concave dorsal margin (fig. 28). Male genital valves with hairs restricted to edges (fig. 11) . . *L. polonica*
- Pedestal on ventral margin of PII twice as long as wide, twice as long as distal spine. PIV with straight or slightly convex dorsal margin (fig. 29, 31). Male genital valves also with hairs between anterior and central acetabula (fig. 6, 12, 13) 8
8. PIV strongly curved in distal part and more slender. Ventral pair of hairs on PIV more centrally; distance between ventral hairs and distal end of PIV 2× length of PV (fig. 29) . . . . . *L. curvipalpis*
- PIV less curved at distal part and not distinctly more slender than proximal part. Ventral hairs of PIV distally; distance between ventral hairs and distal end of PIV 1× length of PV (fig. 30-31) 9
9. Large species, III-leg-5 in males usually > 330 µm, in females > 350 µm. Chitinous parts red. Number of hairs between anterior and central acetabula in both sexes 8-13 (fig. 13, 22) . . . . . *L. undulatoides*

- Smaller species, III-leg-5 in males < 270 µm, in females <300 µm. Chitinous parts yellowish to yellowish-brown. Number of hairs between anterior and central acetabula in both sexes up to 9, but usually 5-7 (fig. 12, 21) . . . . . *L. undulata*

SPECIES DESCRIPTIONS

In the following species descriptions, the species *Limnesia curvipalpis*, *L. maculata* and *L. marmorata* are treated in more detail than the other six, for which we refer to Smit & Van der Hammen (2000).

Limnesia connata Koenike, 1895

Limnesia nigra Kramer, 1879; *Limnesia connata*; Viets 1936 (partim); Besseling 1964; Van der Eijk 1977.
Diagnostics By far the smallest species of the genus in the Netherlands, females 0.5-0.65 mm, males even smaller (Viets 1936). Second palpal segment with a small spine, which is not on a pedestal. Closest to *L. tundrosum* Tuzovskij, 1997 and/or *jacziewski* Biesiadka, 1977, which may be the same species. Both species are distinctly larger than *L. connata* with III-leg-5 and III-leg-6 larger than 150 µm, while in *L. connata* they are less than 140 µm.
Distribution In the Netherlands, this species is mainly found in the lower part of the country, where the soil is peaty. The species is rarely found on sandy soils or in brooks.
Biology According to Böttger (1972), referring to Sokolow (1924, 1925), this species does not have a parasitical larval stage. The nymphs, rather than the larvae, leave the egg-mass capsule.
Ecology Although widely distributed in the Netherlands, a rather scarce species which is not numerous anywhere.

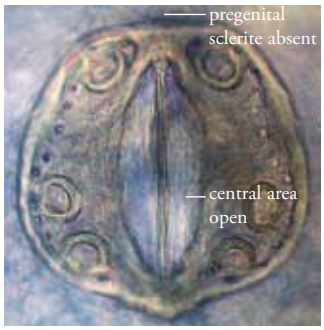
Limnesia curvipalpis Tuzovskij, 1997
New for the Netherlands

Limnesia undulata; Viets 1936 (partim); Van der Eijk 1977 (partim).

Material Berkhorstven (AC 189.42-388.12), 20.vi.2005, 1 male, 4 female; 3.vii.2006, 5 males, 8 females; Valckeniersvennen (AC 112.563-396.083), 14.v.2007, 5 females. Engebeek near Roosendaal (AC 89.66-395.86), 22.ix.2008, 1 male.

Diagnostics A medium-sized species. The specimens we have seen have chitinous parts of a greybrownish colour. Otherwise, it closely resembles *L. undulatoides*, a species of bright purple-reddish colour, and *L. undulata*, a yellowish species. The pedipalps have a strikingly long 4th segment, the distal part being thin and curved and twice as long as the PV. In *L. undulatoides* and *L. undulata* the length of PV is about as long as the distal part of PIV. The genital valves are similar to those of *L. undulatoides* but with fewer hairs.
Distribution Here recorded for the first time from the Netherlands, with four records from the southern part of the country (see details in ecology section). It is quite possible that some records of *L. undulatoides* mentioned in Smit & Van der Hammen (2000) actually refer to *L. curvipalpis*, as it was so far unknown from western Europe. *L. curvipalpis* is also known from Russia: lakes in Yaroslavl region (Tuzovskij 1997), Denmark and France (H. Smit, pers. comm.).
Biology Unknown.
Ecology In the Netherlands this species was found in two moorland pools and a eutrofic canal. In Russia known from lakes (Tuzovskij 1997). In the Netherlands, three known localities. Below, these are described in more detail.
The Berkhorstven (fig. 35) is found in the southeast of the Netherlands, in the northern part of the province of Limburg. It is the core of a small nature reserve in an otherwise agricultural area (mainly livestock breeding industry). It was probably excavated for extracting sand and nowadays forms a shallow moorland pool of 50 by 100 m in size.

Figure 5-13. *Limnesia* males, genital field.
Figuur 5-13. *Limnesia* mannetjes, genitaalveld.



5. *Limnesia connata*

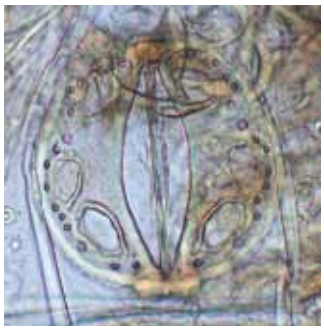
6. *Limnesia curvipalpis*

7. *Limnesia fulgida*

8. *Limnesia koenikei*

9. *Limnesia maculata*

10. *Limnesia marmorata*

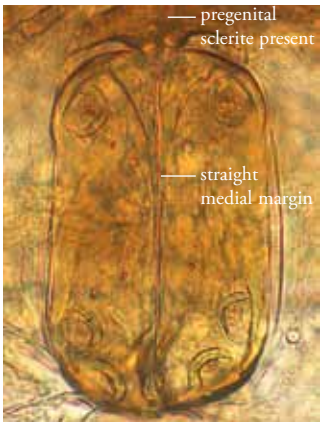


11. *Limnesia polonica*

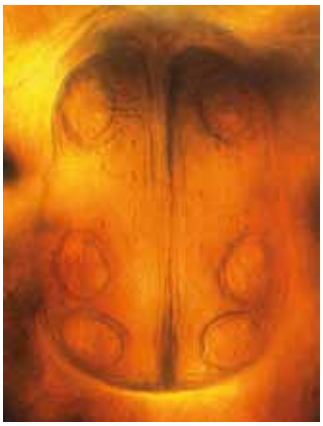
12. *Limnesia undulata*

13. *Limnesia undulatoides*

Figure 14-22. *Limnesia* females, genital field.
Figuur 14-22. *Limnesia* vrouwtjes, genitaalveld.



14. *Limnesia connata*



15. *Limnesia curvipalpis*

16. *Limnesia fulgida*

17. *Limnesia koenikei*

18. *Limnesia maculata*

19. *Limnesia marmorata*

20. *Limnesia polonica*

21. *Limnesia undulata*

22. *Limnesia undulatoides*

Location	Date	n	conductivity µS/cm	pH	Cl^- mg/l	SO_4^{2-} mg/l	Ptot mg/l	Ntot mg/l	H_2CO_3 mg/l
Berkhorstven	20 June 2005	1♂, 4♀	38	6.0	6.3	21	< 0.1	1.8	< 5
Berkhorstven	3 July 2006	5♂, 8♀	46	6.3	7.0	15	< 0.1	2.7	< 5
Valckeniersven	14 May 2007	5♀	63	6.5	9.6	5	0.02	1.4	14.3
Engebeek	22 Sept. 2008	1♂	480	7.4	39	35	0.19	3.91	130

Table 2. Year average of the main parameters from the locations where *L. curvipalpis* was found.
Tabel 2. Jaargemiddelde van de belangrijkste parameters van de locaties waar *L. curvipalpis* is gevonden.

In 2005, its edges were well covered with *Eleocharis multicaulis* Smith. The water is colourless and clear. By Dutch standards, the water is slightly acidic and oligotrophic (table 2). In 2006 *L. curvipalpis* was collected once more, with *Arrenurus albator* (Müller, 1776), *Hydrachna globosa* (De Geer, 1778), *Mideopsis orbicularis* Soar, 1904, *Neumania deltoides* (Piersig, 1894), *Forelia liliacea* (Müller, 1776), *Piona pusilla* (Neuman, 1875), *P. variabilis* (Koch, 1836) and three other *Limnesia* species: *L. koenikei*, *L. maculata* and *L. undulatoides* as accompanying species.

The Valckeniersvennen form a series of moorland pools near Breda, Brabant. The area is well forested. The Valckeniersvennen (fig. 36), where *L. curvipalpis* was found, probably was excavated several 100 years ago for peat extraction. It is more or less circular in shape, 40 m wide and 0.5 m deep. The water is permanent, nearly neutral in acidity, containing clear, but brownish water. By Dutch standards, the water is mesotrophic (table 2). In 2007, *Nymphaea alba* L. dominated most of the open water. Along the edges *Eleogiton fluitans* (L.) and *Utricularia australis* R. Br. are locally numerous to dominant, along and on the banks *Eleocharis multicaulis* Smith and *Molinea caerulea* (L.) are found. *Limnesia curvipalpis* was found along with eight more species of water mite: *Arrenurus buccinator* (Müller, 1776), *A. crassicaudatus* Kramer, 1875, *Hydrodroma despiciens* s.l. (Müller, 1776), *Hydrochoreutes krameri* Piersig, 1896, *Limnesia fulgida*, *Neumania deltoides*, *Piona pusilla* and *Tiphys ornatus* Koch, 1836 (Wilhelm & Tempelman 2008).

The Engebeek is a canal located near Roosendaal (province of Brabant). It is about 12 m wide and 1 m deep. Its water is of brownish colour, slightly alkaline and eutrophic. The banks are lined with trees, providing shade. The soil is clayish and covered with a thick layer of leaves and other organic matter. The submerse vegetation is limited to some *Ceratophyllum demersum* and *Hydrocharis morsus-ranae*. A single *L. curvipalpis* male was found together with the following water mite species: *Arrenurus crassicaudatus*, *Limnesia maculata*, *L. undulata* and *Piona rotundoides* (Thor, 1897).

Limnesia fulgida Koch, 1836

Limnesia histrionica auct. nec. Hermann, 1804; *Limnesia fulgida*; Viets 1936; Besseling 1964; Van der Eijk 1977.

Diagnostics A rather large species within the genus. The chitinous parts are a stunning purple and the second segment of the pedipalp bears a short style which is positioned on a short pedestal. Male genital plates typically with numerous marginal hairs and thickened outer edge. Also the first coxal plates are very typical for this species as they are separated medially by a short inner margin.
Distribution Common in the Netherlands.

	maculata		*marmorata*	
	female	male	female	male
	n=11	n=14	n=10	n=13
III-leg-4	310-370	310-350	220-280	230-260
III-leg-5	330-400	330-380	250-280	250-300
III-leg-6	280-330	290-350	210-260	210-270
IV-leg-4	370-430	360-420	250-310	250-300
IV-leg-5	370-430	370-420	260-320	260-310
IV-leg-6	380-450	370-430	250-310	250-320

Table 3. Length of the 4th, 5th and 6th segment of the 3rd and 4th leg (Dutch specimens).
Tabel 3. Lengte van het vierde, vijfde en zesde pootlid van het derde en vierde pootpaar (Nederlands materiaal).

Recorded from most parts of the country, but largely absent from clay areas in the northeast and southwest.
Biology The larvae attach themselves to adult water beetles (Piersig 1896-1899). Sparing (1959) has found larvae attached to adult chironomids, and explicitly states she could not confirm Piersig's claim concerning its parasitism of water beetles. The larvae cling to thorax and head of their host. In one case, parasitism of the adult fly *Sphaerocera paracrenata* Duda, 1920 (Diptera: Sphaeroceridae) was recorded (Sparing 1959).
Ecology *Limnesia fulgida* occurs in fresh, non-acidic, eutrophic, standing waters in most parts of the country. It is largely absent from the clayish, moderately brackish to saline waters in the north-east and southwest of the country.

Limnesia koenikei Piersig, 1894

Limnesia koenikei; Viets 1936; Besseling 1964; Van der Eijk 1977.

Diagnostics A rather small species, almost always yellow. The style on the inner distal margin of PII is robust, long and is not positioned on a pedestal. The acetabulae in the genital fields are large. The male has strongly curved, laterally angular, genital plates.
Distribution This species is largely confined to the sandy, eastern and southern part of the Netherlands. Here, the species is mainly found in brooks. In some cases the species is found in lakes. Furthermore the species is common on the Wadden Island of Texel.
Biology Unknown. A non-parasitic species?
Ecology In the Netherlands, rather confined to small, flowing waters like the upper reaches of brooks. These brooks may have high nutrient levels; for example, total-nitrogen levels up to 10 mg/l are tolerated. Sometimes it occurs in lakes. It is common in the east, but scarcely found in the western part of the country, lacking from the clayish sub-sea level area.

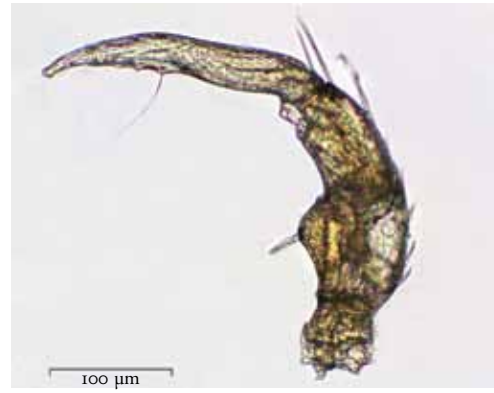
Limnesia maculata (Müller, 1776)

Hydrachna maculata O.F. Müller, 1776: p. 191; *Limnesia oblonga* Koch, 1837: H6.18; *Limnesia magna* Kramer, 1879: p. 10; *Limnesia maculata* f. *brevivalvata* Lundblad, 1924: p. 68-69; *Limnesia turki* Fountain, 1949; *Limnesia maculata* (Müller); Neuman 1880; Lundblad 1920; Soar & Williamson 1927; Tuzovskij 1997; Viets 1936 (partim); Besseling 1964 (partim); Van der Eijk 1977 (partim).

Diagnostics Large species with the chitinous parts usually dark red. Second palpal segment with a short distal pedestal and a small backwardly directed spine. First coxal plates not fused, but nearly touching medially. This species is similar to *L. marmorata* but on average it is larger, with longer legs and palps and red in colour. *Limnesia*

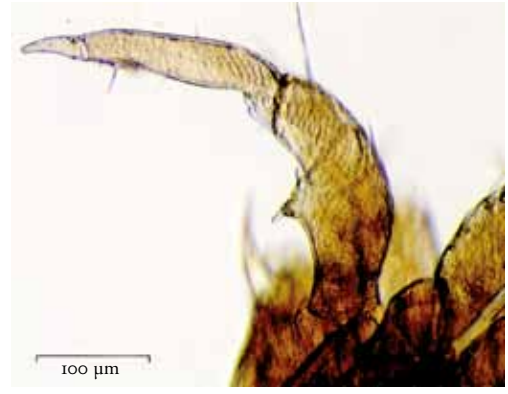
Figure 23-26. *Limnesia*, pedipalp without (23-24) or small (25-26) distal pedestal on inner margin of PII.
Figuur 23-26. *Limnesia*, palp zonder (23-24) of met kleine (25-26) distale sokkel aan binnenzijde PII.

23. *Limnesia connata*



24. *Limnesia koenikei*

25. *Limnesia maculata*

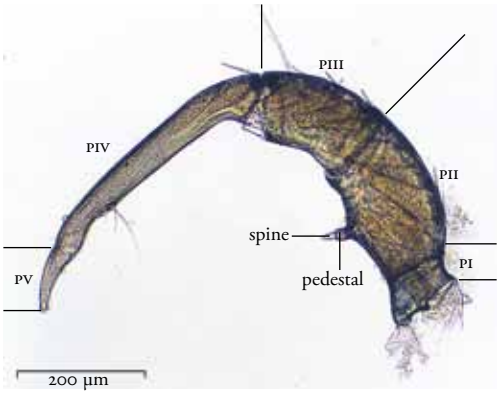


26. *Limnesia marmorata*

marmorata is a small species, with shorter legs and palps and yellow to greyish. The difference in length can easily be seen, when measuring the fourth, fifth or sixth segment of the third and fourth leg (table 3). Although the body length is not diagnostic, *L. maculata* is usually larger, reaching up to 2 mm, while *L. marmorata* reaches only to about 1.5 mm. *Limnesia maculata* also has more swimming hairs than *L. marmorata*. III-leg-4 and -5 have 10-14 hairs each in *L. maculata* and 5-9 in *L. marmorata*. In *L. marmorata* females, the genital valves are distinctly longer than wide and the distance between the anterior and central acetabula is much larger (at least 1.5×) than the width of the central acetabula. In male and female *L. maculata* the genital valves are more or less rounded and the acetabula are closely together. The distance between the anterior and central acetabula is at most the width of the central acetabula. See figure 32 and table 3 for a comparison of both species.

Distribution The species has been found in Denmark (Lundblad 1920), Russia (Karelia, Ozoliņš 1931), Germany (Baden-Württemberg), Italy (Sardinia, Abruzzo) (pers. comm. R. Gerecke), Estonia, Latvia and Austria

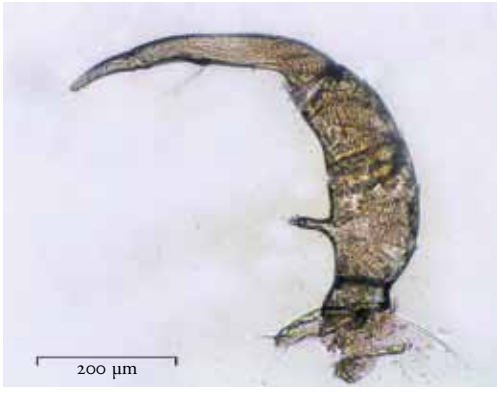
Figure 27-31. *Limnesia*, pedipalp with pedestal on inner margin of PII. In figure 31 PI broken off.
Figuur 27-31. *Limnesia*, palp met sokkel aan binnenzijde PII. In figuur 31 PI afgebroken.



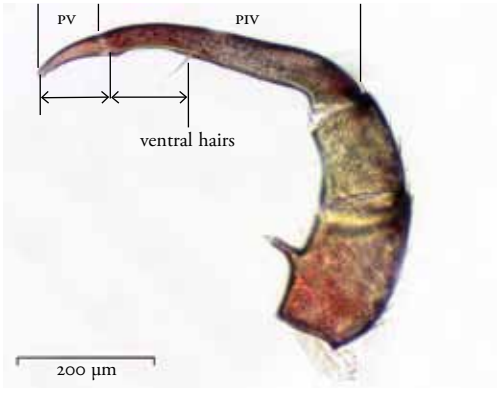
27. *Limnesia fulgida*

28. *Limnesia polonica*

29. *Limnesia curvipalpis*



30. *Limnesia undulata*



31. *Limnesia undulatoides*

	Visibility	Oxygen	Conductivity	pH	Cl-	SO_4^{2-}	Ptot	Ntot
	cm	mg/l	µS/cm		mg/l	mg/l	mg/l	mg/l
number of records with data	24	21	24	21	18	18	18	17
maculata								
mean value	84	6.7	593	7.4	58	54	0.16	3.6
maximum value	250	13.5	1170	8.3	120	135	0.37	8.6
minimal value	20	3.0	232	6.0	27	6	0.03	1.1
number of records with data	24	24	24	24	20	15	20	20
marmorata								
mean value	58	7.7	862	7.8	132	72	0.23	4.4
maximum value	103	14.0	3260	8.6	421	102	1.04	10.5
minimal value	25	2.4	423	6.9	28	33	0.06	1.7

Table 4. Selected parameters of 25 locations where *L. maculata* and *L marmorata* were found numerously. Given values for visibility, oxygen, conductivity and acidity (pH) are based on data corresponding to the capture of the water mites. Values for chloride (Cl^-), sulphate (SO_4^{2-}), phosphorous (P_{tot}) and nitrogen (N_{tot}) are based on averages of year round sampling. Data from 2006-2007 mainly from the western part of the Netherlands.
Tabel 4. Geselecteerde parameters van 25 locaties waar *L. maculata* en *L.marmorata* in grote aantallen zijn aangetroffen. De meetwaardes voor doorzicht, zuurstof, geleidbaarheid en zuurgraad (pH) zijn gebaseerd op de waardes die gemeten zijn ten tijde van het verzamelen van de watermijten. De meetwaardes voor chloride (Cl^-), sulfaat (SO_4^{2-}), totaal-fosfaat (P_{tot}) and totaal-stikstof (N_{tot}) betreffen de jaargemiddelde van het jaar waarin de mijten verzameld zijn. De vangsten hebben alleen betrekking op de jaren 2006-2007 en komen voornamelijk uit het westelijke deel van Nederland.

(Bregenz) (authors' collection). According to Lundblad's earlier papers and the reference list of his 1956 book (includes Sokolow 1930) Lundblad was aware of the existence of both *L. maculata* and *L. marmorata.* So his records of Portugal, Spain, Germany and Switzerland of *L. maculata* must have been based on the actual *L. maculata* (Lundblad 1956). The species is common in the Netherlands. *Limnesia maculata* is probably a Palaearctic species.

Biology This is arguably the best known species of the genus. In an elegant study, Sparing reports parasitism of the species: the larvae cling to adult chironomids, dorsally and ventrally on the thorax as well as on the head (Sparing 1959). Later, the biology of *L. maculata* is described in detail by Böttger (1972). He conducted studies in a laboratory and made field observations on the biology, and host-parasite relationship of this species. Böttger found that *L. maculata* larvae attach to the pupae of chironomids (non-biting midges). They attach to the ventral side of the cephalothorax of the pupa but at first remain only phoretic (non-feeding). The larvae actively move over to the midge as it emerges from the pupa. They then mainly cling to its neck region and start feeding. After four days the larva is fully fed and drops from the host, 'hopefully' into water. Then it transforms into a predatory nymph and later into an adult. In his laboratory study, Böttger (1972) reports offered *Chironomus* species as host and in his field observations *Parachironomus* spec. and *Polypedilum nubeculosum*. Böttger was apparently unaware of the existence of *L. marmorata*, as he gives no reference to it. It was Wainstein (1977) who first gives details on the differences in biology of both closely related species. These differences are remarkable. He confirms that in

Presence of submerged vegetation (total 25 records)	*maculata*	*marmorata*
present	18	5
marginally present	6	7
absent	0	11
no data	1	2

Table 5. Presence of submerged vegetation of localities where *L. maculata* and *L. marmorata* were found most numerously. Data from 2006-2007 mainly from the western part of the Netherlands.
Tabel 5. Aanwezigheid van ondergedoken waterplanten op de locaties waar *L. maculata* en *L. marmorata* abundant zijn aangetroffen. De vangsten hebben alleen betrekking op de jaren 2006-2007 en komen voornamelijk uit het westelijke deel van Nederland.

L. maculata larvae are parasites of adult chironomids. In *L. marmorata*, by contrast, the larvae develop into nymphs within the egg-mass capsule, meaning there is no parasitism in this species. This also leads to differences in physiology and morphology. The most striking feature is that in larvae of the parasitic *L. maculata* the body (dorsal shield) is smaller than in the non-parasitical sibling species *L. marmorata*, but, at the same time, the legs of the larvae of *L. marmorata* are shorter than those of *L. maculata*.
Davids & Kouwets (1984) carried out an extensive study on the host-parasite relationship of water mites and chironomids. They found only few parasitic *L. maculata* (giving no reference to any further species within the genus *Limnesia*). Its hosts were *Microtendipes pedellus* and *Dicrotendipes nervosus/tritomus*. It is remarkable that within the chironomids, only species belonging to the tribe Chironomini are affected (Böttger 1972, Davids & Kouwets 1984).
Ecology The ecological differences between both species have not yet been fully analysed. However, it seems that *L. maculata* is a species of less eutrophied waters, with low nutrient levels, clear waters with good development of submerse vegetation. *Limnesia marmorata* mainly occurs in waters of less ecological quality, meaning, waters with less visibility, vegetation and more heavily eutrophied. In this respect, a remark by Lundblad (1962) is interesting. On page 103 he states '…the grey form *L. marmorata* is biologically peculiar, because both Neuman (1880) and Walters (1908) and my own observations show that it has a more benthic life than the red nominate form'.
Of both species, around 100 records were available for analysis. However, this was based mainly on records originating from the western part of the country, with only a few from the sandy region of the country. On first sight little difference is apparent: most records originate from ditches or similar watercourses, with a slight bias for peaty soils in *L. maculata*. Also, *L. marmorata* is less present in brooks than its sibling (fig. 39).

From the hundred or so records of both species, we analysed the 25 locations where the species were found most numerously. In table 4 and 5 a series of physical and chemical parameters of the water at the relevant locations are shown. Nine parameters were selected: presence of submerged vegetation, visibility, oxygen saturation level, conductivity, acidity and concentration levels of chloride, sulphate, phosphorous and nitrogen.
It needs to be emphasized that most records originate from the western part of the country, where most waters are very eutrophic. However, several differences which seem significant do emerge. Considering nutrient levels, *L. marmorata* is found in waters with higher nitrogen levels, conductivity and chloride concentration. Differences in phosphorous are indistinctive. Sulphur also apparently is indistinctive, although this is uncertain as data are partly lacking. So far, this matches with the concept of *L. marmorata* being the species which is more tolerant to poorer water quality. Paradoxical as it may seem, the mean oxygen saturation level in waters were *L. marmorata* has been found is higher. This however relates to measurements at day time, when in many coastal waters the micro algae produce large quantities of oxygen. At night the oxygen level in many of those waters is very low. So *L. marmorata* is tolerant of unstable oxygen levels. In our opinion, the

Figure 32. Left: *Limnesia maculata*, female. Right: *L. marmorata*, female. Note the striking difference in size and colour.
Figuur 32. Links: *Limnesia maculata*, vrouw. Rechts: *L. marmorata*, vrouw. Let op het grote verschil in grootte en kleur.

most striking difference between both species is the presence of submerged vegetation. In almost all places where *L maculata* has been found numerously, submerged vegetation was well de veloped. In localities with many *L. marmorata* it is mostly absent or only marginally developed.

Limnesia marmorata Neuman, 1870
New for the Netherlands

Limnesia marmorata Neuman, 1870: p. 109, type locality Lake Mälaren 1866; *Limnesia maculata* var. *viridis* Udalzow, 1907: p. 245. Syn. nov.; *Limnesia maculata* var. *marmorata* Neuman; Lundblad 1912: p. 227-230; *Limnesia maculata* var. *angustata* Sokolow, 1930: p. 333-334. Syn. nov.; *Limnesia maculata* Müller; Viets 1936 (partim); Besseling 1964 (partim); Van der Eijk 1977 (partim); *Limnesia maculata viridis* Udalzow; Dresscher 1954; *Limnesia angustata* (Sokolow); Wainstein 1977; Tuzovskij 1997.

Diagnostics A medium-sized species with chitinous parts yellowish. Resembles *L. maculata* but has smaller legs and palps. In females, the genital field is of a striking, elongated shape. See paragraph dealing with *L. maculata* and table 3 for differentiating features with *L. maculata*. The size of several leg segments of the type material (measurements by the authors of this paper) and as given in Tuzovskij (1997) are on average a little larger than in the Dutch material. For instance, in Dutch material, the IV-leg-5 length reaches up to 320 µm, while one female of Neuman's material had a IV-leg-5 length of 340 µm; Tuzovskij

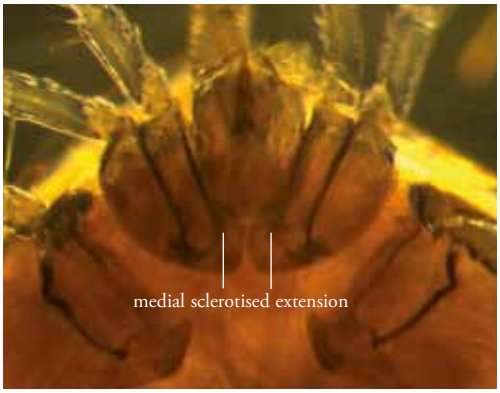


Figure 33. *Limnesia fulgida* female, first two coxal plates with typical medial margin.
Figuur 33. *Limnesia fulgida* vrouw, eerste twee coxaalplaten met typische binnenrand.

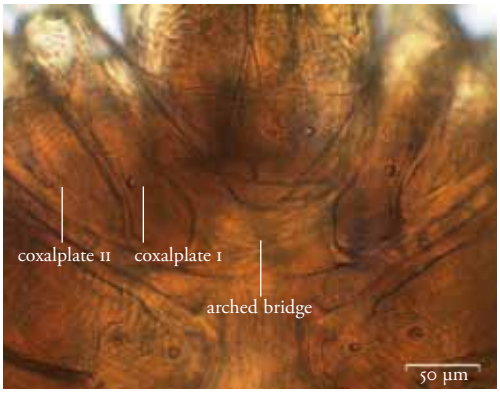


Figure 34. *Limnesia polonica* coxal plates I and II with arched bridge.
Figuur 34. *Limnesia polonica* eerste twee coxaal platen met chitine brug.

(1997) gives a range of up to 360 µm. However in all cases the genital field of the females were of the typical elongated shape.
Distribution Denmark (Lundblad 1920), Sweden (Lundblad 1962; type material, collection Göteborgs Naturhistoriska museum), Russia (Karelia, Ozoliņš 1931 and St. Petersburg Province (Sokolow & Yankowskaya 1962), Italy (Sardinia, pers. comm. R. Gerecke), Austria (Bodensee, authors' collection), probably Switzerland or France (Walter 1928 as *L. variegata*) and Alaska (Marshall 1924 as *L. elliptica*). Viets (1930) gives an unverified record of '*L. maculata*' from Spain. *Limnesia marmorata* is very common in the Netherlands, even more than *L. maculata*.
Biology According to Wainstein (1977), this species does not have a parasitical larval stage. See also under *L. maculata*.
Ecology A very common species in canals, ditches and lakes in the Netherlands. In most cases, submerged vegetation is absent. In Dutch large rivers it is almost the only *Limnesia* species. According to Lundblad (1920), in Denmark it is more or less a typical inhabitant of lakes. Lundblad hasn't seen the species outside lakes. According to our data, the species is tolerant towards instable oxygen levels, its occurrence not being linked to the presence of submerged vegetation and is found in very nutrient rich waters. See also under *L. maculata* for ecological data.
Taxonomy *Limnesia marmorata* was first described as a separate species by Neuman (1870, 1880). In most 20th century literature, this species was treated as being merely a form, variety or subspecies of *L. maculata* (Lundblad 1912, 1962, Sokolow 1930, Viets 1936, 1956, Besseling 1958, 1964). However, they clearly differ in morphology as well as biology and have therefore to be considered distinct species (Wainstein 1977). Wainstein retains the name *L. maculata* for the red 'form', calling the yellow 'form' *L. angustata*. The name '*angustata*' is from Sokolow (1930) who used it to designate a 'variety' of *L. maculata*. So Wainstein (1977) raises *Limnesia maculata* varietas *angustata* to the species level (*L. angustata*).
Tuzovskij (1997) gives a revision of the genus, re-describing all *Limnesia*-species. He concurs with Wainsteins assertion about the specific status of both yellow and red species. The yellow 'form' is once more called *L. angustata*. This *L. angustata* however also fits the description of *L. marmorata* given by Neuman (1880). In size (small) and colour (yellow), Neumans' *L. marmorata* indeed is similar to *L. undulata* (see textbox 'In search of the correct name of *Limnesia marmorata*'), but not to *L. maculata*, a large species which is red.

Figure 35. The Berkhorstven near Ysselsteyn, 20 June 2005. Note massive amount of *Eleocharis multicaulis*. Photo Jeroen van Mil.
Figuur 35. Het Berkhorstven nabij Ysselsteyn, 20 juni 2005. Let op de dominantie van *Eleocharis multicaulis*. Foto Jeroen van Mil.

Figure 36. The Valckeniersven near Breda, 14 May 2007. *Nymphaea alba* is the most striking macrophyte. Photo Arthur van Dulmen.
Figuur 36. Het Valckeniersven nabij Breda, 14 mei 2007 met *Nymphaea alba* als meest opvallende waterplant. Foto Arthur van Dulmen.

The morphology of its palps however is similar to that of *L. maculata*. Neuman (1880) gives no full description of the genital fields nor measurements of the leg segments. Fortunately the type material (5♂ and 2♀), collected by Neuman in 1866 in Lake Mälaren, were stored in the Göteborgs Naturhistoriska museum and available for study. These Swedish specimens match the Dutch specimens of *L. marmorata*: the genital field of both Swedish and Dutch specimens is similar, the female specimens showing their unique, elongated shape of the genital valves. Although several leg segments of the Swedish specimens are on average a little longer than those of the Dutch specimens, they are within the ranges given by Tuzovskij (1997) (details see under 'Diagnostics'). We have not been able to study Sokolow's type material of '*Limnesia maculata* varietas *angustata*'. However as Tuzovskij (1997) gives a re-description of this former 'variety', including all necessary details

Figure 37. The Keulevaart. On 18 August 2006, 38 individuals of *Limnesia maculata* were found, along with many *L. undulata* but no *L. marmorata*. Photo Arthur van Dulmen.
Figuur 37. De Keulevaart. Op 18 August 2006 zijn hier 38 individuen van *Limnesia maculata* gevonden, tezamen met vele *L. undulata* maar geen *L. marmorata*. Foto Arthur van Dulmen.

Figure 38. Ditch in the province of Zuid-Holland. On 21 May 2007, 176 individuals of *Limnesia marmorata* were found here, not accompanied by other *Limnesia* species.
Figuur 38. Sloot in de provincie Zuid-Holland. Op 21 mei 2007 zijn hier 176 individuen van *Limnesia marmorata* gevonden, zonder enige andere *Limnesia* soort.

(e.g. of measurements and shape of the genital fields), we expect that a study of the type material should not lead to a different opinion. Therefore, in our opinion, *Limnesia marmorata* described by Neuman in 1880 is the same species as *Limnesia maculata* varietas *angustata* described by Sokolow in 1930 (which was eventually re-described in Tuzovskij in 1997). This means *L. angustata* is a junior synonym of *L. marmorata*.

Limnesia polonica Schechtel, 1910

Limnesia polonica; Viets 1936; Besseling 1964; Van der Eijk 1977.

Diagnostics Small species. Chitinous parts yellowish with a hint of orange. First coxal plates interconnected with a small arched bridge and the second palpal segment with a ventral median pedestal which is as short as the distal spine.

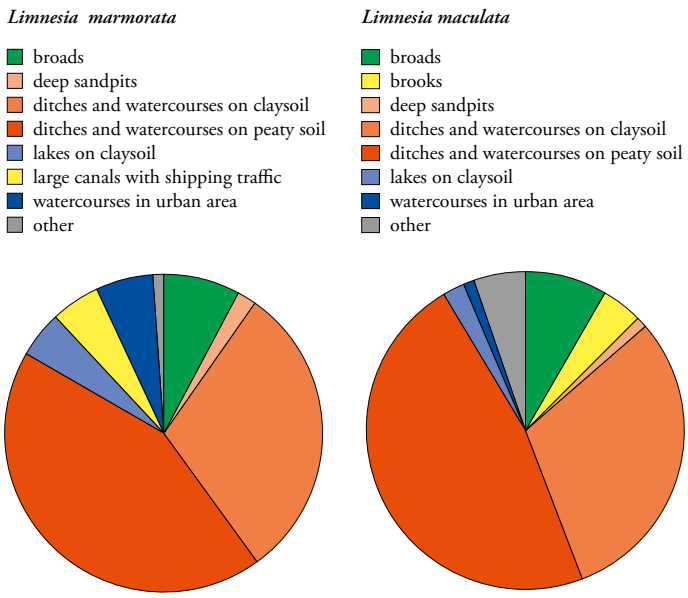


Figure 39. Habitat preference of *Limnesia maculata* and *L. marmorata*.
Figuur 39. Habitatvoorkeur van *Limnesia maculata* en *L. marmorata*.

This combination of characters is typical for this species. Also in the male genital valves the hairs are more or less restricted to its edges.
Distribution Rare. In the Netherlands, rather common in the broads near Amsterdam ('Vechtplassengebied') but very rare elsewhere.
Biology Unknown.
Ecology According to Smit & Van der Hammen (2000) this species is found in oligo- to mesotrophic waters. However, the broads near Amsterdam, with more than 90% of the Dutch records, are meso- to eutrophic clear, standing waters with well developed submerged vegetation.

Limnesia undulata (Müller, 1776)

Limnesia pardina Neuman, 1880; *Limnesia undulata*; Soar & Williamson 1927; Viets 1936 (partim); Besseling 1964 (partim); Van der Eijk 1977 (partim); *Limnesia heteropora* Tuzovskij, 1997.

Diagnostics Small species with chitinous parts yellowish. It is further characterized by its long pedestal on the ventral margin of the second palpal segment, its short fourth palpal segment and the shorter legs. The first coxal plates are interconnected with an arched bridge.
Distribution Very common in the Netherlands, but largely lacking from the sea clay, brackish parts in the southwest and northeast.
Biology According to Böttger (1972), referring to Sokolow (1924, 1925), this species does not have a parasitical larval stage. Böttger adds that this is confirmed in Szalay (1928). However, these authors were unaware of the existence of the sibling species *L. undulatoides*, which was described by Davids (1997). As is the case in the siblings *L. maculata* and *L. marmorata*, in the sibling pair *L. undulata* and *L. undulatoides* only one of both species has a parasitical life stage. *Limnesia undulata* is the non-parasitical of both species. So the eggs develop into nymphs, which at some point leave the egg mass-capsule.
Ecology The commonest species of the genus, found in eutrophic, standing waters, with or without submerged vegetation.

Limnesia undulatoides Davids, 1997

Limnesia undulata; Viets 1936 (partim); Tuzovskij 1997.

Diagnostics This species was described by Davids (1997), his publication preceding Tuzovskij's key by only six months. It is closest to *L. undulata* but its general size and shape are more like *L. fulgida*: a large, brightly coloured species with red legs and pedipalps. Acetabulae remarkably small, when compared to those of *L. maculata*. Also rather close to *L. curvipalpis*, but that species has a strongly curved and longer 4th pedipalpal segment and is more or less yellowish-brown and not brightly red as in *L. undulatoides*. Also *L. undulatoides* has longer legs.
Distribution A fairly common species in the Netherlands. In 2007, this species seems to be less common than in the 1990s. Besseling (1948) was already aware of a blue-red form of *L. undulata* also present in the Netherlands, referring to Lundblad (1929). However, he says it was just a colour form of *L. undulata*. As Neuman's 1880 description of *Limnesia histrionica* (Hermann, 1804) is identical to *L. undulatoides*, the species is probably also present in Sweden. Records from Alaska and Canada (e.g. in Marshall 1924 as *L. histrionica*) need to be verified. The original description of *L. histrionica* Hermann however, is actually not a *Limnesia* species (pers. comm. H. Smit), but due to misinterpretation of this description, records of *L. histrionica* may be a collection of many species, including *Limnesia*.
Biology Of the siblings *L. undulata* and *L. undulatoides*, this latter species has a parasitical life stage. Davids (1997) gives no information on the hosts of this species.
Ecology Found in eutrophic, standing waters, most of which have well developed submerged vegetation.

DISCUSSION

It is likely that more *Limnesia* species occur in Western Europe than known at present. Tuzovskij (1997) keys out *L. walteri* Migot, 1926 (close to *L. polonica*) and several new species. *L. media* (close to *maculata*), *L. kamtschatica* (close to *L. undulata*), *L. tundrosum* (close to *L. connata*) and *L. caucasica* (close to *L. koenikei*). Most of these species have so far only been recorded from Russia. From Poland *L. jaczewskii* Biesiadka, 1977 was described, which resembles *L. connata*. However, it is unclear whether *L. jaczewskii* and *L. tundrosum* are distinct species.

We suggest all water mite workers to keep notes of these water mites. It would be useful to review material of various European regions. Measuring leg length, shape and size of genital valves and acetabula and body colour helps and making notes of the water from which the specimens have been captured should help contributing to the knowledge of these species. If necessary, specimens can be identified by the authors. An English translation of Tuzovskij's key is available on request.

Normally, in the 'water mite world' knowledge increases through captures of rare species. In this case, this concerns common species. This makes all the more apparent that water mites remain an exciting field of study, and that this may greatly increase ones knowledge of the Russian language too!

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SUMMARY

De Nederlandse *Limnesia*-soorten, met ecologische en biologische aantekeningen (Acari: Hydrachnidia: Limnesiidae)

Van het watermijtengeslacht *Limnesia* waren tot voor kort zeven soorten uit Nederland bekend. In dit artikel worden hier twee soorten aan toegevoegd: *Limnesia marmorata* Neuman, 1870 en *L. curvipalpis* Tuzovskij, 1997. Het aantal bekende soorten watermijten in Nederland stijgt daarmee tot 248.

Limnesia marmorata werd in de Westerse literatuur als vorm, variant of ondersoort beschouwd. In Russische literatuur werd ze wel als zelfstandige soort beschouwd, echter onder de naam *L. angustata*. Omdat de oorspronkelijke beschrijving van *L. marmorata* en het typemateriaal hiervan uit het Mälaren-meer (Zweden) overeenkomt met de latere beschrijving van *L. angustata* moet *L. angustata* met *L. marmorata* worden gesynonymiseerd. *Limnesia marmorata* is morfologisch nauw verwant aan *L. maculata* Müller, 1776 maar is daarvan te onderscheiden door zijn gele kleur, zijn kleinere gestalte en de vorm van de geslachtsorganen; *L. maculata* is rood en duidelijk groter. Ook de biologie van beide zustersoorten is sterk verschillend; *L. maculata* heeft parasitaire larven, *L. marmorata* is een niet-parasitaire soort. *Limnesia marmorata* is in Nederland een zeer algemene soort in allerlei voedselrijke wateren en heeft waarschijnlijk een benthische levenswijze. In tegenstelling tot *L. maculata* komt deze soort ook voor in wateren zonder ondergedoken of drijvende vegetatie. *Limnesia maculata* is vooral te vinden tussen de ondergedoken waterplanten in niet al te verontreinigde wateren. Deze soort is dan ook een indicator voor betere waterkwaliteit.

De tweede nieuwe Nederlandse soort, *Limnesia curvipalpis* is nauw verwant aan *L. undulata* (Müller, 1776) en *L. undulatoides* Davids, 1997. *Limnesia curvipalpis* heeft echter een afwijkend gevormd vierde palplid. De soort is in Nederland in een tweetal vennen en een eutroof kanaal gevonden.

In deze publicatie wordt een overzicht gegeven van de negen in Nederland voorkomende *Limnesia*-soorten. Tevens wordt een determinatietabel voor de negen soorten gegeven. Voor elke soort wordt een beschrijving gegeven van de verspreiding, ecologie en biologie, indien bekend.

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