BULLETIN ZOOLOGISCH MUSEUM

UNIVERSITEIT VAN AMSTERDAM

Vol. 10 No. 14 1985

THE LARVAE OF THREE WATER MITE SPECIES OF THE GENUS *HYGROBATES* AND THEIR DEVELOPMENT (ACARI, HYDRACHNELLAE)

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ABSTRACT

The larvae of *Hygrobates longipalpis*, *H. nigromaculatus* and *H. trigonicus* are described, the latter for the first time. The characteristics of *H. longipalpis* and *H. nigromaculatus* larvae are compared with descriptions in existing literature. Data on laying period, characteristics of the eggs and egg hatching time for the three species are given. The larvae of *H. nigromaculatus* develop into nymphs without a parasitic phase.

INTRODUCTION

In the course of long term studies of life history and predation biology of *Hygrobates longipalpis* (Hermann, 1804), *H. nigromaculatus* Lebert, 1879 and *H. trigonicus* Koenike, 1895, it was possible to rear the eggs and describe the larvae. The description provided below follows that of Prasad & Cook (1972) (see fig. 1 for explanation of the lettering).

Hygrobates larvae have a large dorsal plate, almost entirely covering the length of the idiosoma. The dorsal plate bears four pairs of propodosomal setae. The epimeres (coxal plates) I, II and III on each side are fused, and bear four pairs of setae. The excretory pore plate is large and much wider than long. The setae, E1 and E2, on the excretory pore plate, are absent or very small. The ventral setae, V2, are located on the excretory pore plate. The ventral setae, V4, usually called caudal setae, are very long and are borne on elongate projections.

The larvae of the genus *Hygrobates* can be distinguished from the related genus *Atractides* by the location of the ventral setae, V1, on the posterior end of the epimeres (Prasad & Cook, 1972; Wainstein, 1980).

In general, there are three active stages in the life cycle of water mites: the larva, (deuto)nymph and adult. The larval stage is usually parasitic on aquatic or semi-aquatic insects, while the nymph and adult are typically freeliving predators. As early as the turn of the century Piersig (1879-1900) knew that the life cycle of some species differs from this typical pattern of development. According to him, the larvae of *Brachypoda versicolor*

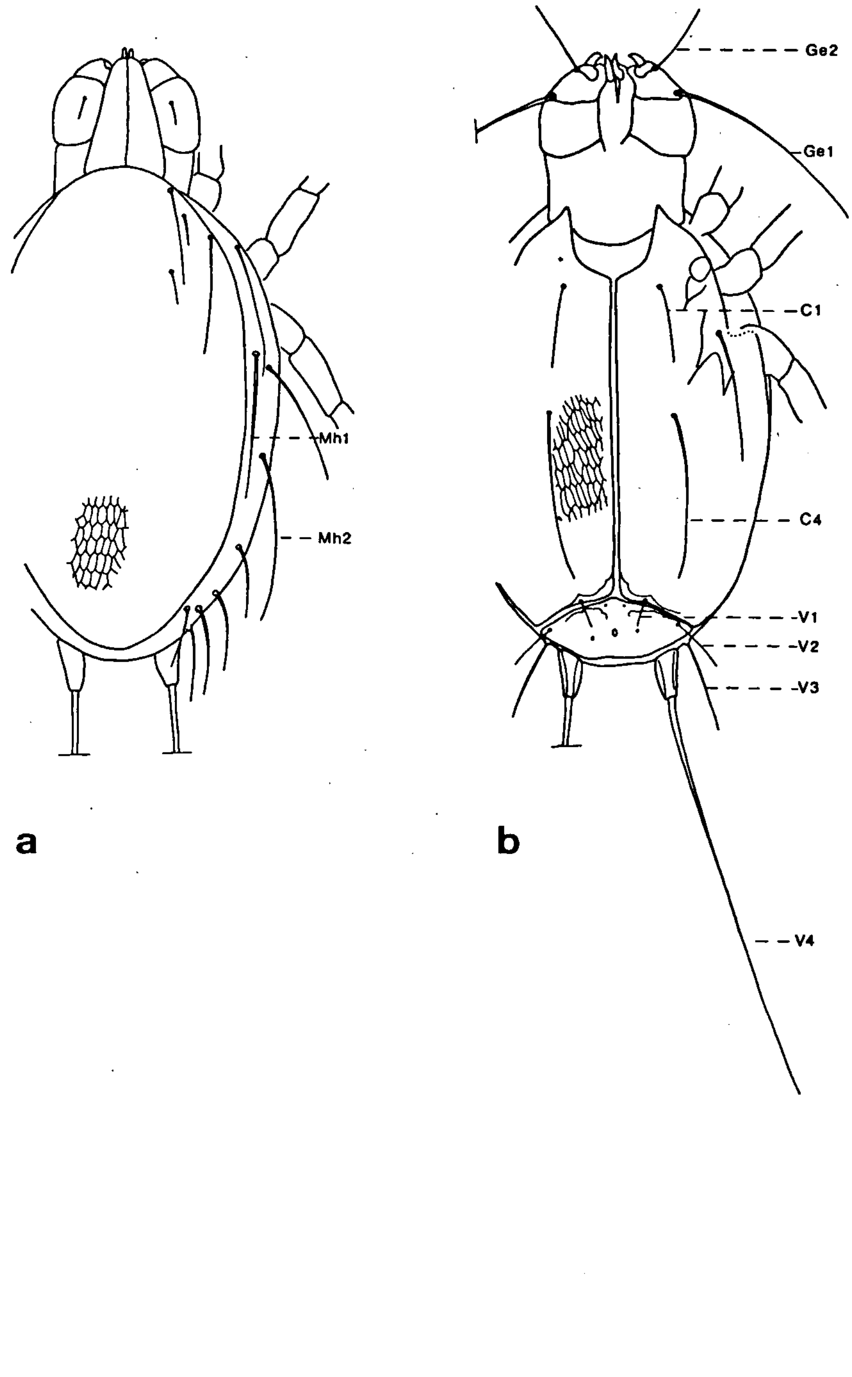

Fig. 1. *Hygrobates longipalpis* larva. a, dorsal; b, ventral (Mh1, Mh2: (medio)hysterosomal setae, Ge1, Ge2: setae of the palpal genu, C1-C4: coxal setae, V1-V4: ventral setae).

(Müller, 1776), *Limnesia connata* Koenike, 1895 and *Limnesia undulata* (Müller, 1776) do not have a parasitic phase but develop almost immediately into nymphs, often without leaving the protective layer surrounding the egg cluster.

Böttger (1962) described the production of two types of eggs by *Piona nodata* (Müller, 1776): small ones (190-195 μm) in spring, and large ones (270 μm) in summer. Small larvae hatch from the small eggs. In absence of a host, they die after about ten days. The large eggs yield large larvae, which pass into the transformation stage leading to the deutonymph after 2 or 3 days. Often the larvae transform within the protective layer surrounding the egg cluster. For the genus *Hygrobates*, the absence of a parasitic phase in the life cycle is unknown.

Methods.-

The three species of *Hygrobates* were collected in Lake Maarsseveen I, the Netherlands. The collections were made early in May 1984 and in the latter part of September 1984. After collection, the adult mites were anaesthetized by means of urethane and the species and sex were determined. Females of the three species were placed in vials and kept at varying temperatures that approximated observed temperatures throughout spring and summer in the field. Ample food was added in the form of chironomid larvae, which are natural prey for all three species (Motas, 1928).

The vials were inspected twice a week for eggs. Resulting egg clusters were removed to separate vials and incubated at field temperatures. The development of the embryos was observed and the newly hatched larvae were reared to examine further development.

Several larvae were prepared for microscopic investigations. Measurements of the larvae were made, using the methods of Prasad & Cook (1972), except for the length of the legs, which was measured excluding the claws.

Results.-

All three species produced eggs when the experiment was started in mid-May. *H. longipalpis* deposited large egg clusters, averaging 23 eggs per cluster (8 to 61, n = 21). The clusters were more or less circular in outline, and usually consisted of more than one layer. The average diameter of the eggs was 171 μm (95% confidence limits: 162-180). After the beginning of August, when ambient temperatures reached 23°C, no more eggs were produced.

H. nigromaculatus deposited its eggs in clusters of 4 to 5 eggs (1 to 12, n = 19). These clusters were usually one, and occasionally two layers thick. The average diameter of the eggs was 194 μm (95% c.l.: 180-208). The average ashfree dryweight was 3.2 μg per egg (n = 109) (J.G. de Nobel, pers. comm.). After mid-June, when ambient temperatures reached 17°C, no more eggs were produced.

The egg clusters of *H. trigonicus* consisted of 2 to 3 eggs (1 to 6, n = 18), which were often deposited in rows. The average diameter of the eggs was 153 μm (95% c.l.: 139-167). The average ashfree dryweight was 1.4 μg per egg (n = 74) (J.G. de Nobel, pers. comm.). After mid-August, when ambient temperatures reached 23°C, no more eggs were produced.

Of the females collected in September, only *H. trigonicus* deposited a few eggs on one occasion. Both other species failed to produce eggs in late summer.

From the eggs of all three *Hygrobates* species larvae hatched. The eggs of *H. nigromaculatus* deposited in April, hatched after an average period of 49 days (temperature range 7-16°C) (E.H. ten Winkel, pers. comm.). Later in the season, the egg hatching time declined; the eggs laid mid-May hatched after 21 days (temperature range 13-16°C), while those deposited mid-June hatched after 10 days (temperature range 16-20°C) (see fig. 4). A similar decrease in egg hatching time was found for *H. longipalpis* and *H. trigonicus*. The eggs deposited mid-May hatched after 21 and 24 days, respectively (temperature range 13-16°C), while those laid at the beginning of July hatched after 11 and 10 days, respectively (temperature range 20-23°C).

The larvae of *H. longipalpis* and *H. trigonicus* died, in absence of a host, after 7 to 25 and 5 to 25 days, respectively. The larvae of *H. nigromaculatus* required initially 10 days, and later in the season 5 days, to develop into nymphs without a parasitic stage. Occasionally the larvae transformed into nymphs within the protective layer surrounding the egg cluster.

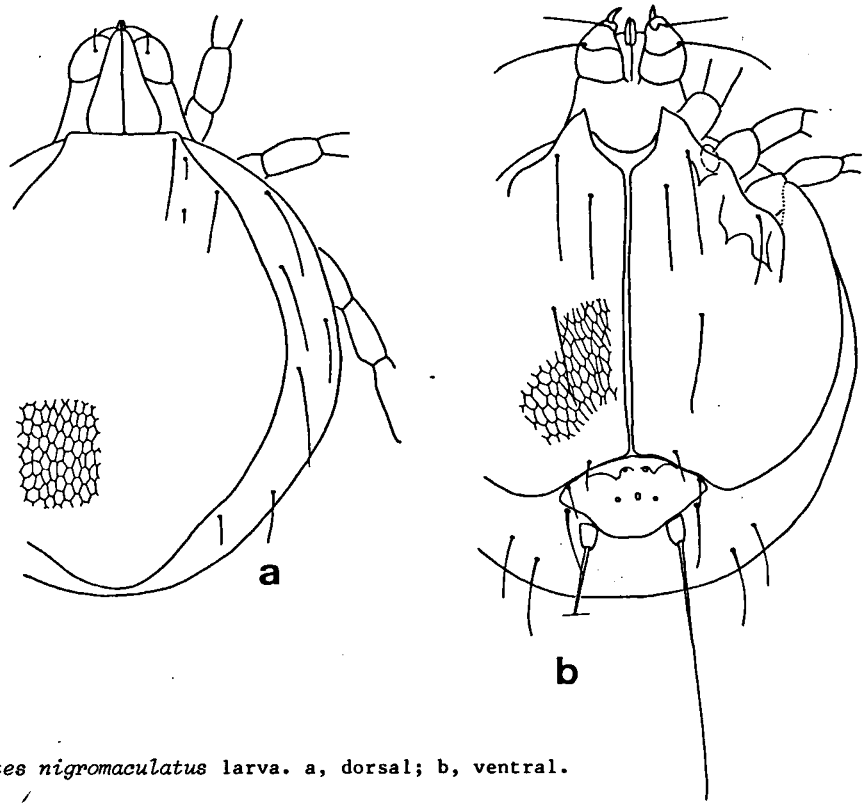

Fig. 2. *Hygrobates nigromaculatus* larva. a, dorsal; b, ventral.

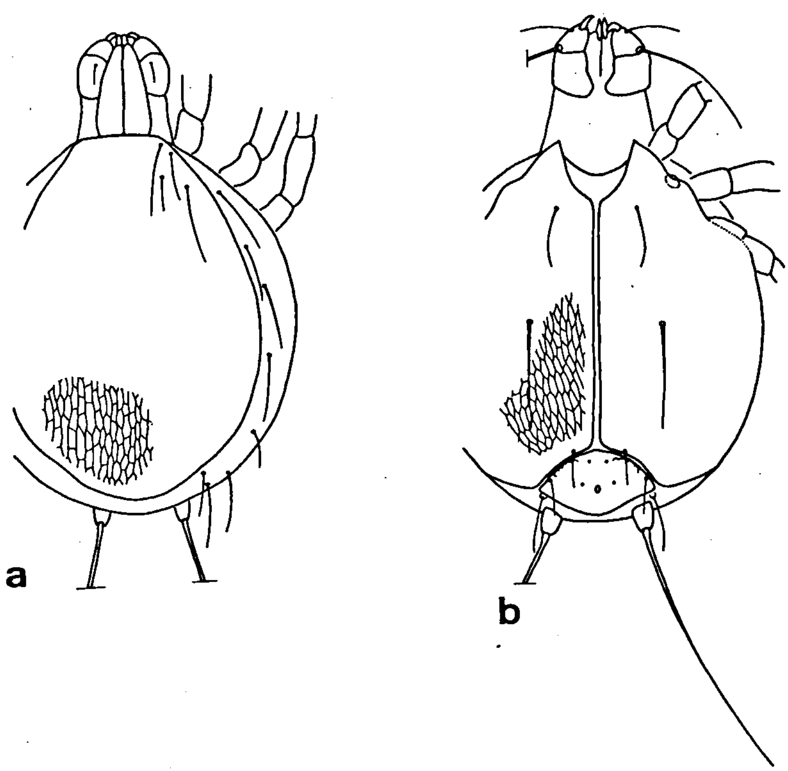

Fig. 3. *Hygrobates trigonicus* larva. a, dorsal; b, ventral.

THE MORPHOLOGY OF THE LARVAE

Hygrobates longipalpis
(fig. 1, table I)

The main characteristics are:

The larva is oval in shape. The dorsal plate is approximately twice as long as wide (1.90 to 2.13, mean 1.98, n = 10) and is rounded anteriorly. The pattern on the posterior part of the dorsal plate is punctate and oblong reticulate. The hysterosomal setae are long and heavy. The epimeres are long and narrow. The medial notch on the anterior edge of the epimeres is somewhat wider than deep. The coxal setae, C4, are long, but not extending beyond the posterior margin of the epimeres. The excretory pore plate is more than twice as wide as long (2.19 to 2.41, mean 2.32, n = 10) and slightly W-shaped posteriorly. The caudal setae, V4, are long and located on projections, which are approximately twice as long as wide (1.93 to 2.23, mean 2.06, n = 11).

Hygrobates nigromaculatus
(fig. 2, tabel I)

The main characteristics are:

The larva is nearly round. The dorsal plate is approximately 1½ times as long as wide (1.31 to 1.62, mean 1.46, n = 6). The anterior margin is truncate. The pattern on the posterior part of the dorsal plate is punctate and reticulate. The hysterosomal setae are thin and moderately long. The epimeres are wide. The notch on the anterior part is somewhat wider than deep. The excretory pore plate is about twice as wide as long (1.63 to 2.08, mean 1.98, n = 8). The caudal setae, V4, are moderately long and the projections, on which they are located, are approximately 1½ times as long as wide (1.25 to 1.82, mean 1.47, n = 8).

Hygrobates trigonicus
(fig. 3, table I)

The main characteristics are:

The larva is small, oval to round. The dorsal plate is approximately 1½ times as long as wide (1.30 to 1.54, mean 1.47, n = 10). The anterior margin is truncate. The reticulate pattern on the posterior part of the dorsal plate is elongate, the lines that run longitudinally being clearly more prominent. The planes, of this pattern, lie more or less in rows, and are punctate. The epimeres are narrow and short. The anterior notch is approximately as wide as deep. The coxal setae, C1, are thin and short. The setae, C4, are somewhat heavier. The excretory pore plate is less than twice as wide as long (1.65 to 1.89, mean 1.77, n = 10). The caudal setae, V4, are moderately long and the projections, on which they are located, are about 1½ times as long as wide (1.25 to 1.83, mean 1.46, n = 9).

Discussion.-

For all three *Hygrobates*-species the time between egg deposition and hatching of the larvae diminished strongly with increasing temperatures. The eggs, which *H. nigromaculatus* deposited at the beginning of its laying period (temperature 7-16°C) required for development five times longer than those deposited at the end of the laying period (temperature 16-20°C). Stechmann (1978) established a similar dependence on temperature for *Arrenurus cuspidator* (Müller, 1776) and *A. buccinator* (Muller, 1776). He reported that at a temperature of 18-22°C the egg hatching time was 13-14 days. At a temperature of 8-10°C, however, the egg hatching times was 108-120 (*A. cuspidator*) and 66-72 days (*A. buccinator*). Ullrich (1976) found for *Hygrobates calliger* Piersig, 1896 and *H. fluviatilis* (Ström, 1768) an egg hatching time of 30-33 days at a temperature of 13°C, which can be considered to be within the same range as our results.

The life cycle of *Hygrobates nigromaculatus* differs from that which is typical for water mites. The larvae of this species develop directly into nymphs without undergoing a parasitic phase. This development corresponds with that of *Brachypoda versicolor*, *Limnesia connata* and *Limnesia undulata* (Piersig, 1897-1900) and with that of the large summer eggs of *Piona nodata*, as is described by Böttger (1962). The eggs deposited by *Hygrobates nigromaculatus*, were of the same size throughout the year. They were larger than those of *H. longipalpis* and *H.*

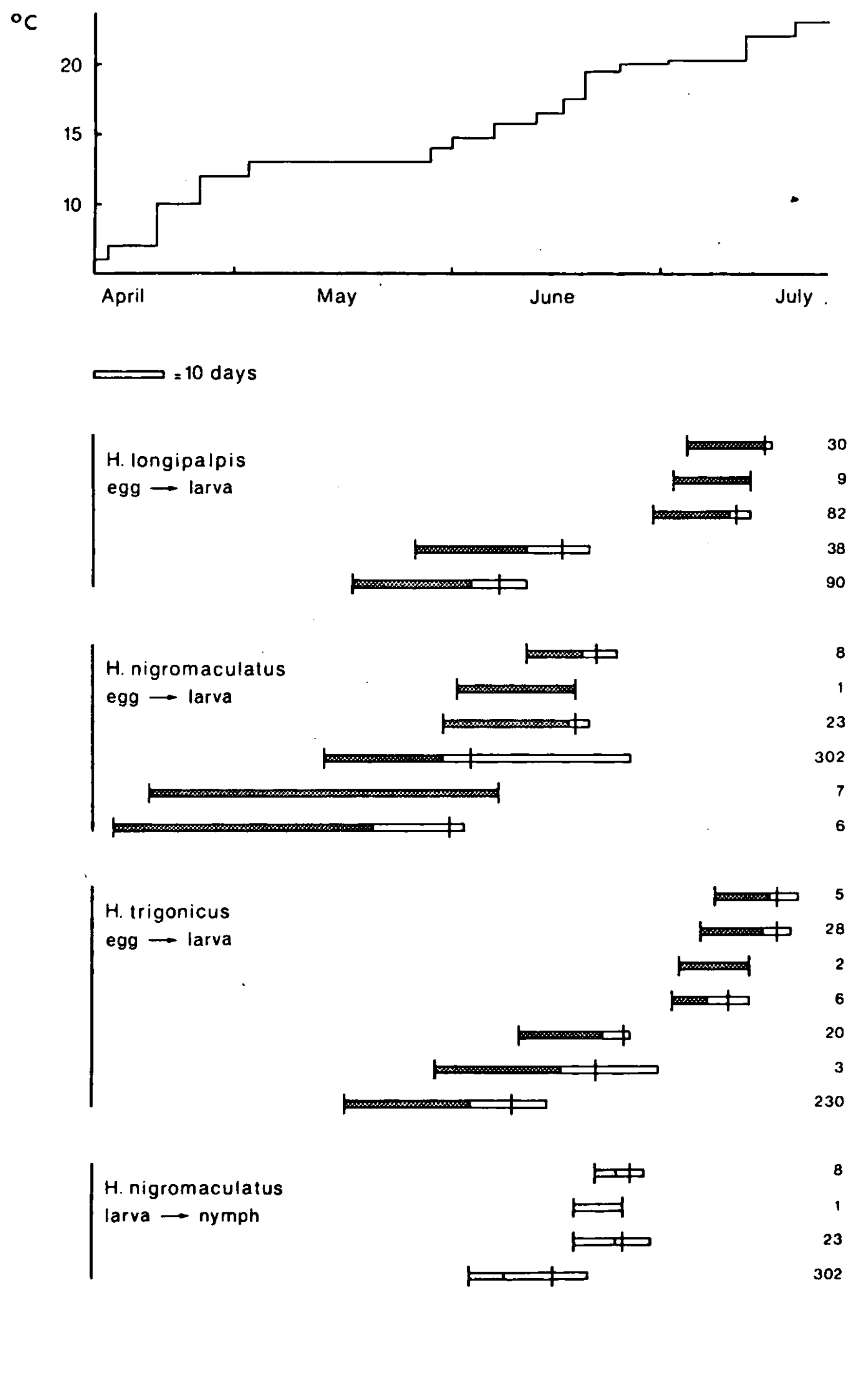

Fig. 4. Egg hatching time for the three *Hygrobates* species and development time required for the larva of *H. nigromaculatus* to produce the nymphal stage. Mean and range values are indicated, as well as the number of eggs or larvae observed. The upper graph shows the temperatures during the experimental period.

trigonicus, both being species of which the larvae do have a parasitic phase. Larvae of *H. longipalpis* have been found parasitizing on various chironomid imagines near Lake Maarsseveen I (Kouwets & Davids, 1984). Larvae of *H. trigonicus* have been found (E.H. ten Winkel, pers. comm.) on imagines of *Cladotanytarsus mancus* (Walker). Parasitic larvae of *H. nigromaculatus* are not reported in the available literature.

The larvae of *Hygrobates longipalpis* can be clearly distinguished from those of *H. nigromaculatus* and *H. trigonicus* by the dorsal plate and epimeres, which in *H. longipalpis* are more oblong. Additionally the dorsal plate is rounded anteriorly, and many of the setae are longer, specifically the setae of the palpal genu, Ge1 and Ge2, the hysterosomal setae and the caudal setae, V4. The larvae of *H. nigromaculatus* and *H. trigonicus* resemble one another closely. *H. trigonicus* can be distinguished by its smaller size. This is especially evident in the size of the dorsal plate and the epimeres. The dorsal plate of *H. trigonicus* measures 220 x 150 µm, while that of *H. nigromaculatus* is 297 x 201 µm. The epimeres of *H. trigonicus* are 148 x 93 µm in size, while those of *H. nigromaculatus* are 176 x 131 µm. It should be noted however, that the epimeres are often difficult to measure, as they are bent around the body of the larvae. The most striking difference between the two species is to be found in the pattern on the plates, particularly the dorsal plate. The reticulate pattern of *H. trigonicus* is more oblong, the planes of which lie more or less in rows. Prasad & Cook (1972) are of the opinion that these patterns, especially on the posterior part of the dorsal plate, may be specific.

Specimens of *H. longipalpis* from the Soviet Union, as described by Wainstein (1980), merely differ in detail. The caudal setae, V4, are markedly short (105 µm) in comparison with those specimens from the Netherlands (237 µm). The American specimens of *H. longipalpis* larvae, as described by Prasad & Cook (1972), differ in some important aspects. The larvae are much smaller and more rounded in outline. The anterior margin of the dorsal plate is truncate and not rounded as is characteristic for the Euro-Asian *H. longipalpis*. It is possible that the Euro-Asian *H. longipalpis* and the North American forms represent variations on the subspecies level. A comparable phenomenon is described for *Unionicola* species by Crowell & Davids (1979).

The description provided by Wainstein of the larvae of *H. nigromaculatus* corresponds in general with that provided in this study. There are, however, some minor differences. As a result, Wainstein's taxonomic key to the larvae of the genus *Hygrobates* (Wainstein, 1980) is not applicable to the larvae of *H. nigromaculatus* from the Netherlands. The variability in some of the characteristics for *H. nigromaculatus* appears to exceed the difference between *H. nigromaculatus* and some other *Hygrobates* species. It concerns the following characteristics: the length-width ratio of the dorsal plate and the depth-width ratio of the medial notch on the anterior portion of the epimeres. Using Wainstein's key for distinguishing *H. nigromaculatus* from *H. calliger*, *H. foreli* (Lebert, 1874) and *H. longiporus* Thor 1898 may therefore lead to complications.

H. trigonicus is not included in Wainstein's key. *H. trigonicus*, as described here, does not differ from *H. nigromaculatus* in any of the characteristics Wainstein uses in his key. Thus, the taxonomic separation of the two species appears to require the discrimination in size and the dorsal plate pattern, described in this study.

ACKNOWLEDGEMENTS

The authors would like to thank Drs. E.H. ten Winkel and J.G. de Nobel for placing data at our disposal.

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Table I. Measurements in µm of selected characteristics of *Hygrobates* larvae. For each species the number of observations (n), mean (x), and in parentheses, the range of observed values, are provided.

		H. longipalpis			H. nigromaculatus			H. trigonicus		
		n	x	range	n	x	range	n	x	range
dorsal plate	length	10	297	(288-309)	10	297	(274-321)	10	220	(206-233)
	width	10	150	(143-156)	6	201	(195-209)	10	150	(140-161)
epimeres	length	20	195	(187-206)	18	176	(165-187)	20	148	(143-154)
	width	16	96	(90-103)	17	131	(122-141)	19	93	(83-101)
notch epimeres	depth	8	44	(40- 52)	8	40	(36- 46)	10	40	(36- 45)
	width	8	54	(51- 57)	8	46	(41- 52)	10	41	(37- 43)
excretory pore plate	length	10	38	(36- 42)	8	46	(41- 52)	10	38	(35- 43)
	width	10	89	(84- 98)	8	87	(80- 93)	10	68	(65- 73)
cheliceres	length	20	78	(75- 82)	10	69	(64- 73)	18	65	(60- 73)
	width	20	25	(23- 28)	11	21	(19- 23)	18	17	(14- 21)
leg I	total	10	214	(208-220)	10	184	(173-197)	10	187	(183-190)
	femur	10	45	(42- 47)	10	39	(37- 40)	10	38	(35- 41)
	genu	10	40	(38- 42)	10	33	(31- 36)	10	35	(33- 36)
	tibia	10	49	(48- 51)	10	42	(38- 46)	10	42	(41- 44)
	tarsus	10	61	(59- 65)	10	52	(45- 56)	10	52	(50- 54)
leg II	total	10	248	(239-268)	10	204	(192-214)	10	201	(192-211)
	femur	10	45	(44- 48)	10	38	(35- 40)	10	37	(30- 42)
	genu	10	43	(41- 46)	10	36	(33- 38)	10	35	(33- 37)
	tibia	10	62	(59- 68)	10	50	(45- 52)	10	49	(45- 51)
	tarsus	10	72	(69- 75)	10	59	(56- 66)	10	61	(57- 64)
leg III	total	10	274	(266-288)	10	237	(216-248)	10	227	(218-233)
	femur	10	53	(50- 57)	10	41	(37- 43)	10	41	(37- 44)
	genu	10	50	(49- 53)	10	41	(38- 44)	10	41	(38- 43)
	tibia	10	67	(65- 70)	10	58	(50- 61)	10	55	(53- 57)
	tarsus	10	79	(74- 83)	10	69	(61- 73)	10	66	(64- 68)
setae palp	Ge1	16	125	(116-134)	14	66	(62- 70)	16	78	(71- 87)
	Ge2	9	60	(55- 66)	9	36	(34- 39)	11	31	(21- 38)
idiosoma	Mh1	10	101	(88-110)	9	49	(45- 54)	10	56	(47- 70)
	Mh2	16	104	(98-110)	7	58	(48- 73)	14	50	(45- 57)
	C1	6	45	(33- 59)	9	44	(38- 48)	12	28	(16- 34)
	C4	15	106	(98-113)	10	56	(51- 66)	11	70	(56- 79)
	V2	11	33	(28- 35)	7	23	(19- 27)	10	24	(22- 27)
	V3	19	54	(47- 59)	9	47	(38- 60)	17	38	(31- 45)
	V4	15	237	(223-246)	13	166	(157-177)	17	175	(159-185)
projection V4	length	11	32	(31- 35)	8	16	(15- 18)	9	17	(16- 19)
	width	11	16	(15- 17)	8	11	(9- 13)	9	12	(10- 13)

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Received: 26.II.1985
Distributed: 16.VIII.1985