

SOME MORPHOLOGICAL CHARACTERISTICS OF THE WATER SCORPION *NEPA CINEREA* (HETEROPTERA: NEPOMORPHA) ARE ASSOCIATED WITH HABITAT TYPE*

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Morphological variation can enable species to successfully survive and reproduce in distinct habitats. Water scorpion (*Nepa cinerea* Linnaeus, 1758) occurs in different aquatic habitats from lentic to lotic conditions. We examined the morphology of *N. cinerea* collected from a diverse array of habitat types (creeks, canals, ponds) in order to explore possible morphological adaptations to the habitat. We addressed the following specific questions: (i) is there any morphological differences between specimens collected from distinct habitats, and if so, (ii) is it possible to relate differences in morphology of the *N. cinerea* to characteristics of the habitat structure? Altogether 121 individuals (69 males and 52 females) were sampled from 17 sampling sites in the catchment area of Lake Balaton (Hungary). 54 body parameters were determined on all individuals. According to five habitat parameters (bottom quality, current velocity of the water, water depth, submerse plant density, shading) sampling sites were clustered into two distinct groups. Submerse plant density proved to be the most important discriminating factor between the two groups. The morphology of the *N. cinerea* (both males and females) sampled from the two contrasting habitat types were different. No relationship was found between geographical position of the habitat type and body morphology of *N. cinerea*. Leg morphology, especially claws on the third leg and some body shape parameters showed relationships with habitat characteristics. These morphological variations, which may be the result of phenotypic plasticity, could contribute to an opportunistic habitat choice of the species.

Key words: Nepidae, phenotypic plasticity, submerse vegetation, leg morphology, ordination.

INTRODUCTION

Relationship between body morphology and habitat is a key factor in understanding the mechanisms of evolution (WEST-EBERHARD 1989, VIA *et al.* 1995, AGRAWAL 2001). In the case of water insects some morphological characters as e.g. body size and shape, leg arrangement of populations from various taxa are strongly related to environmental factors as hydraulic conditions,

*This paper dedicated to Prof. László Papp the reknown Diptera taxonomist and insect ecologist former Editor-in-Chief of the *Acta Zoologica Academiae Scientiarum Hungaricae*.

substrate of the bottom or vegetation density (DAHL & PECKARSKY 2002, ORLOFSKE & BAIRD 2014). Benthic organisms are exposed frequently to flowing water. A morphological adaptation of body shape is a way in order to reduce hydraulic stress (STATZNER & HOLM 1982). For example, lack of protected microhabitat had strong effect on stonefly phenotype. FRANKEN *et al.* (2008) showed reduced body size in the case of the stonefly *Nemoura cinerea* (Retzius, 1783) (Plecoptera: Nemouridae) in sandy bottom where refugia were absent. The fan morphology of the blackfly *Simulium lundstromi* (Enderlein, 1921) (Diptera: Simuliidae) larvae was found to be adapted to different current velocities in order to enable sufficient feeding at different flow regimes (ZHANG & MALMQVIST 1997, MALMQVIST *et al.* 1999).

Quantitative studies on the intraspecific phenotypic plasticity of some Nepomorpha species in relation to various habitat parameters have also been performed in some cases. SITES *et al.* (1996) found shape differences among three *Ambrysus mormon* Montandon, 1909 (Naucoridae) populations collected from sites with notably different mean average temperatures. Phenotypic plasticity or modulated ontogeny was suggested as source of intraspecific morphological differences. Morphological adaptation of the wings and legs in relation to the habitat was examined in the case of the corixid *Arctocorisa carinata* (Sahlberg, 1819) (Corixidae) by JANSSON and PAJUNEN (1978). With the aid of multivariate methods it was possible to distinguish morphologically related population groups. Claws of the second leg were found the most important grouping character. The function of these claws is grasping to the bottom. Intraspecific adaptation to the hard bottom was manifested in short claw.

N. cinerea L., 1758 is a common aquatic insect, extensively distributed and frequent in the Palaearctic region (POLHEMUS 1995). Its population density can be high in a wide variety of habitats. Field studies in Norway suggest that this species prefer vegetation rich running waters (e.g. rivers) where sediment is dygyttja or clay/gyttja (COULIANOS *et al.* 2008). LOCK *et al.* (2013) found most specimens in brooks in a country wide sampling program in Belgium. *N. cinerea* was found in moderate density in the reed area of the clear water lakes by VAN DE MEUTTER *et al.* (2005). Small water bodies with varying conductivity, depth and macrophyte coverage were primer habitat for *N. cinerea* in Spain (CARBONELL *et al.* 2011). According to TAMANINI (1979) this species lives near the banks of slow flowing streams, springs, canals and wetlands with aquatic plants and plant debris. In Italy *N. cinerea* is present also in rivers, and in waters without or with scarce vegetation (F. Cianferoni, pers. comm.). Results of GARCÍA-AVILÉS *et al.* (1996) and HUFNAGEL *et al.* (1999) showed that *N. cinerea* occurs frequently in small streams with little current and where the vegetation is abundant. Since the species occurs among diverse environmental conditions it may provide an ideal model to examine the morphological response of aquatic insects to environmental heterogeneity. However, to our knowledge no study to date examined in detail the phenotypical plasticity of *N. cinerea* in response to habitat conditions.

We asked two questions as follows: (i) is there any morphological differences between specimens collected from distinct habitats, and if so, (ii) is it possible to relate differences in morphology of the *N. cinerea* to habitat structure characteristics?

MATERIAL AND METHODS

The samples were taken in small aquatic habitats (e.g. creeks, canals, ponds) in the catchment area of Lake Balaton (Fig. 1) in August 2012. *Nepa cinerea* Linnaeus, 1758 individuals were collected with long handled O-frame water net in a diameter of 25 cm and mesh size 0.5 mm. Altogether 22 sampling sites were examined for *N. cinerea* of which at least one specimen was found in 17 sites (Table 1). Altogether 121 individuals (69 males and 52 females) were sampled. All specimens were stored in 98% ethanol in separate jars. Morphological measurements were performed about one year after sampling. Specimens are deposited at the Department of Zoology and Animal Ecology, Szent István University, Gödöllő. Some sampling sites were selected close to each other, others in more distance in order to eliminate geographical effects as much as possible. Largest distance between

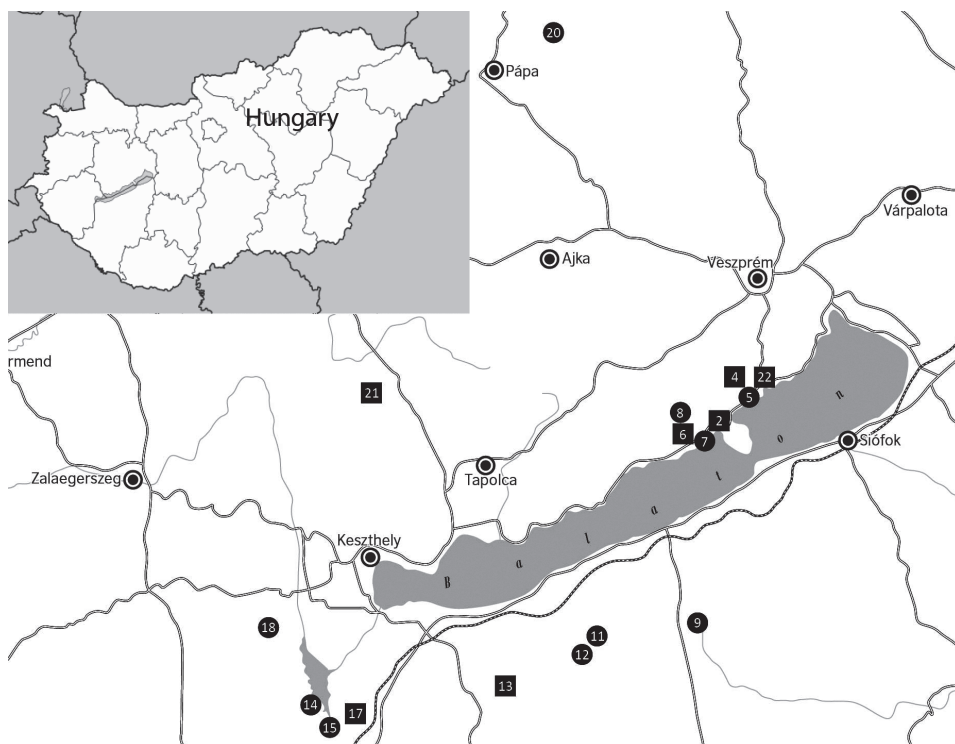


Fig. 1. Location of the sampling sites in the catchment of Lake Balaton, Hungary. Square: sampling sites are belonging to the habitat group A, Circle: sampling sites are belonging to the habitat group B. Sampling sites without *N. cinerea* are not indicated.

Table 1. Sampling sites with some characteristics of the habitat.

No.	Sampling place	No. of <i>N. cinerea</i>	Bottom	Current velocity	Depth [cm]	Macrophyte density [%]	Shadow
1	Tihany (Külső-tó, lower canal)	0	silt	slow	>50	10–25	yes
2	Örvényes (Bázsa creek)	4	silt	slow	<20	25–50	yes
3	Balatonarács (Koloska spring head)	0	gravel	no	>50	10–25	no
4	Balatonarács (Koloska creek, above Koloska csárda)	3	silt	slow	<20	25–50	yes
5	Balatonarács (Koloska creek, below Koloska csárda)	4	silt	slow	<20	0	yes
6	Vászoly (Örvényesi-séd, shallow water)	2	silt	slow	<20	50–80	no
7	Vászoly (Örvényesi-séd, deep water)	10	silt	slow	<20	0	yes
8	Vászoly (Lake Vászoly)	1	gravel	no	<20	1–5	no
9	Kötse (Büdös-gáti-víz)	13	silt	fast	20–50	1–5	no
10	Vadépuszta (Tetves creek)	0	silt	slow	<20	50–80	no
11	Visz (Tetves creek)	10	silt	no	<20	1–5	no
12	Kisberény (Halsok-árok)	14	silt	slow	>50	0	no
13	Nikla (Koroknai creek)	9	silt	slow	20–50	50–80	no
14	Zalakomár (Kiskomáromi canal)	3	silt	fast	<20	1–5	no
15	Ormándpuszta (Zala-Somogyi határárok)	12	silt	fast	<20	1–5	no
16	Nemesvid (Marót-völgyi canal)	0	silt	no	>50	10–25	no
17	Csákány (Marót-völgy)	10	silt	fast	>50	25–50	no
18	Felsővállicka (Söjtől)	3	silt	slow	20–50	0	yes
19	Pölöske (Szévíz)	0	silt	no	<20	0	yes
20	Koronc (Marcal)	1	silt	slow	>50	1–5	yes
21	Megyer (Marcal)	16	silt	slow	<20	80	no
22	Palóznak (Lovasi-séd)	6	silt	fast	20–50	50–80	yes

two sampling sites was almost 120 km (Fig. 1). Five habitat parameters were recorded at all sampling sites, as follows: (1) bottom quality (silt or gravel), (2) current velocity of the water (standing water $<0.1 \text{ m s}^{-1}$; slow, $0.1\text{--}0.5 \text{ m s}^{-1}$; strong, $1.0\text{--}2.0 \text{ m s}^{-1}$ according to NOSEK *et al.* (2007), (3) water depth ($<20 \text{ cm}$, $20\text{--}50 \text{ cm}$, $>50 \text{ cm}$), (4) submerse plant density (evaluated as plant cover per m^2 , 0% , $1\text{--}10\%$, $10\text{--}25\%$, $25\text{--}50\%$, $50\text{--}80\%$, $>80\%$, according to NOSEK *et al.* (2007) and (5) area shaded by vegetation (yes, no).

Body parameters were $\ln(x+1)$ transformed in order to improve normality of the distribution of the data. Raw data of the body parameters were compared between habitat types with two-sampled t-tests (Microsoft Excel) for both sexes separately.

To examine the association between habitat types and *N. cinerea* morphology, first, the habitat parameters of the sampling sites were clustered (Euclidean distance, complete linkage algorithm) to find groupings (i.e. habitat types) among them. After that, a linear discriminant analysis (LDA) was performed to reveal which morphological features differ according to the habitat types. Cluster analysis and LDA were conducted in the R environment (R CORE TEAM 2013). We do not interpret loadings in the structure matrix unless they are 0.2 or higher.

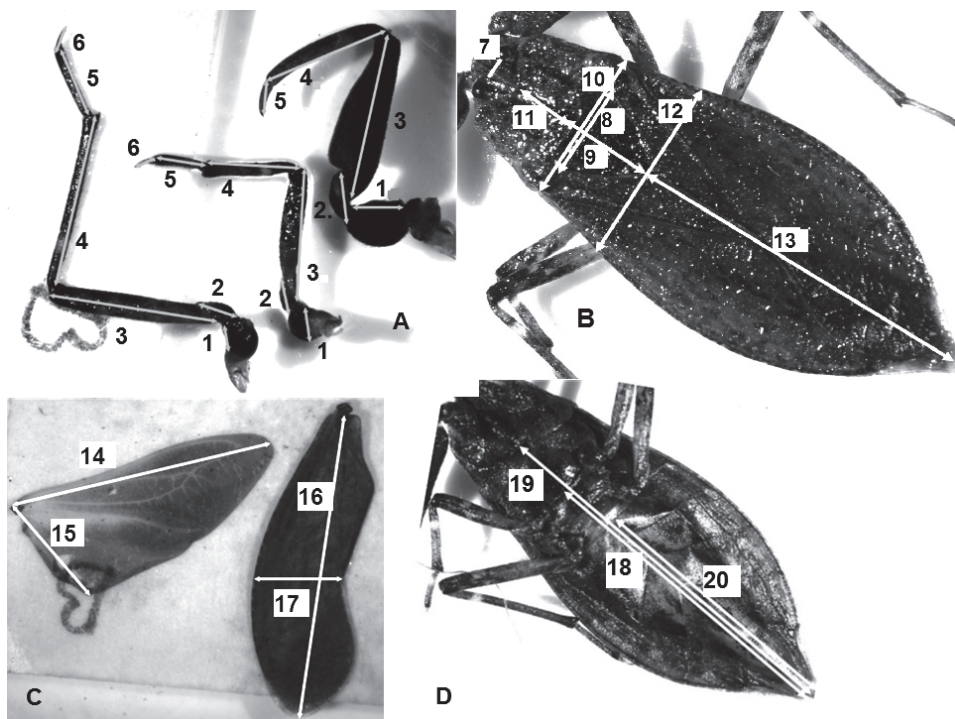


Fig. 2. Position of the measurements. A: lengths of the coxa (1), trochanter (2), femur (3), tibia (4), tarsus (5) and claw (6) on all legs (forelegs do not bear claws), B: distance between the eyes (7), width and length of the scutellum (8–9) and prothorax (10 and 11), width of the mesothorax (12), body length from the end of the scutellum to the anal siphon (13), C: length and width of the first (16–17) and second (14–15) pair of wings, D: distance of the frontal edge of the pro- (19), meso- (18) and metathorax (20) from the anal siphon basis, (anal siphon is not showed).

Landmark based methodology was used for the geometric morphometric analysis. Ten landmarks were defined on the photos made from dorsal view. Landmarks were digitalised using the tipDig 2.17 software (ROHLF 2013). The MorphoJ, version 1.06b program package was used for further analyses (KLINGENBERG 2011). Procrustes fit was performed first. Thereafter covariance matrix was generated and canonical variate analysis (CVA) was performed to test for the existence of differences in body shape between habitats. Sexes were handled separately. Only those sampling sites were included, where at least 5 individuals were collected. Six sites for males and three for females fit this requirement.

RESULTS

Habitats

Sampling sites clustered into two main groups (Mann-Whitney U-test, z -score = -3.4 , $p < 0.001$) (Fig. 3). Seven sampling sites belonged to the group A. This group of habitats could be characterized by rich submersed vegetation. The group B contained ten sampling sites. The main characteristics of these habitats is that they are poor in submersed vegetation. Other habitat parameters (bottom quality, current velocity of the water, water depth and area shaded by vegetation) did not differ considerably between the two habitat groups.

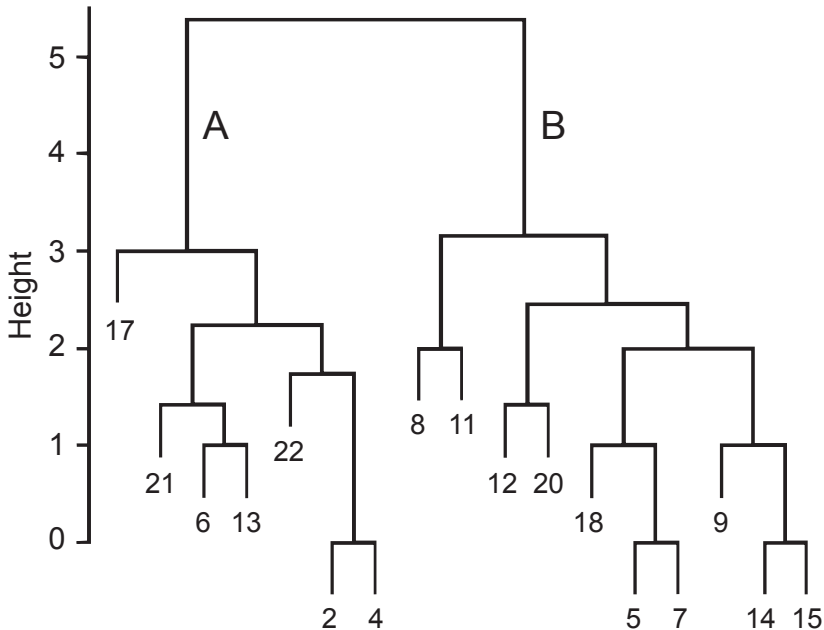


Fig. 3. Two habitat group clusters of the sampling sites. Numbers represent different sampling sites according to the Table 1. A: habitats rich in submersed vegetation, B: habitats poor in vegetation.

The two groups were not related to the geographical position or latitude of the sampling sites. Sampling sites No. 15 and No. 17 were located relatively close to each other in the field, but differences in habitat characteristics were the greatest (Fig. 3). On the other side, the two furthestmost sampling sites (No. 15 and No. 20) belonged to the same cluster.

Morphological differences between sexes

The body length of the male and female *N. cinerea* individuals is considerably different. Average body length \pm SE in millimetre of the male 15.7 ± 0.9 and that of female 18.1 ± 1.3 was different ($t = -12.2$, $p < 0.001$). Significant difference between male and female body length suggests that sex is an important factor, if body morphology is in focus of any study. Substantial overlap in body length distribution was observed between sexes (Fig. 4). Male body length was similar, but that of female was different, if the same sex, belonging to the two habitat groups were compared ($p = 0.24$ and $p = 0.02$ for male and female, respectively).

Association between body morphology and habitat types

Results of the linear discriminant analysis showed that the morphology of the *N. cinerea* (both males and females) were different according to their habitats (Figs 5 & 6). The difference is more expressed in the case of fe-

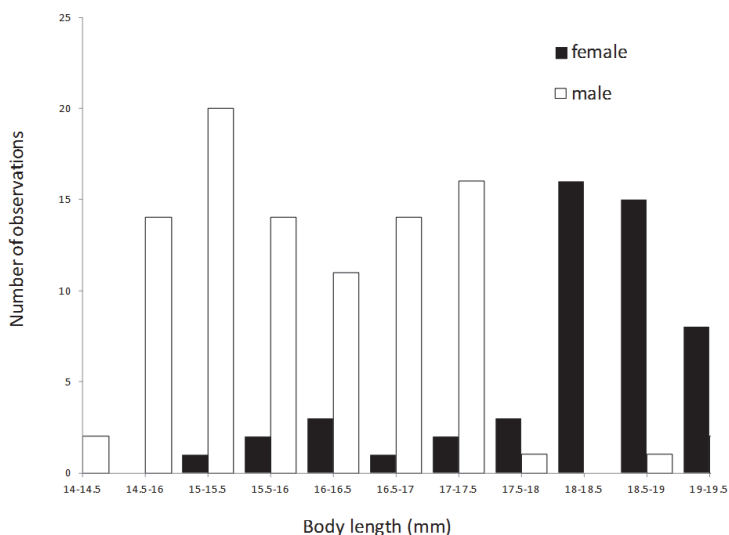


Fig 4. Body length distribution of the *N. cinerea* males and females. All sampled individuals are included.

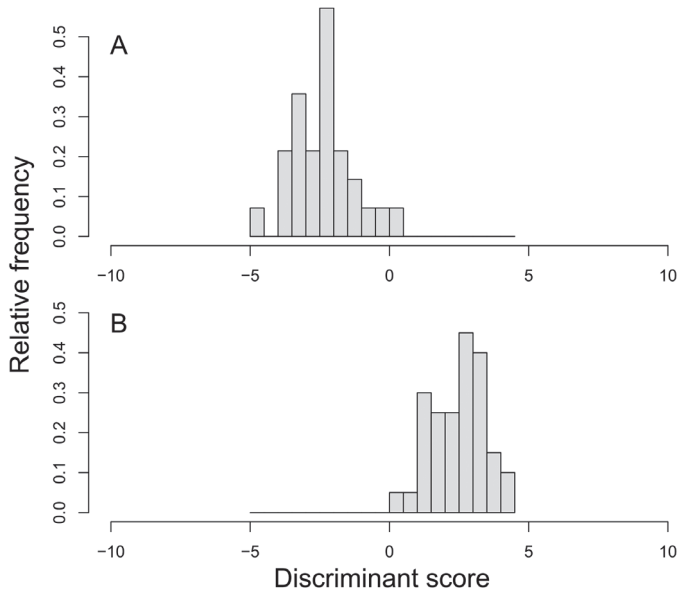


Fig. 5. Two-class linear discriminant analysis for male *N. cinerea* based on measured body parameters. Bar shows frequency distribution of the data. A: specimens belonging to habitats rich in submersed vegetation, B: specimens belonging to habitats poor in vegetation.

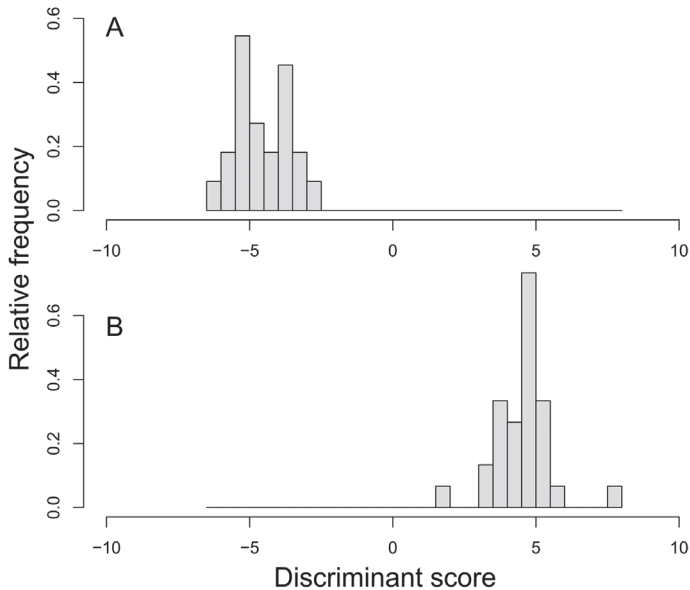


Fig. 6. Two-class linear discriminant analysis for female *N. cinerea* based on measured body parameters. Bar shows frequency distribution of the data. A: specimens belonging to habitats rich in submersed vegetation, B: specimens belonging to habitats poor in vegetation.

males than males. In the case of the females the first linear discriminant (LD1) average \pm SD was -5.22 ± 0.94 and 3.83 ± 1.04 for habitat type A and B, respectively. The difference was not so large if the data of the males is regarded. For males average LD1 \pm SD was -2.85 ± 1.06 and 2.00 ± 0.96 for habitat type A and B, respectively. Different body morphology was found even if the sampling sites of the *N. cinerea* were close to each other, and oppositely, morphologically similar populations were found in notably distant sampling sites.

Geometric morphology analysis strongly supports this statement. Figure 7 shows that males from sampling sites No. 15 and No. 21 are very similar to each other, although the sites in a straight line are as far as 62 km. Oppositely, morphological differences is noteworthy even if the sampling sites are only 18 km from each other (sites No. 9 and No. 12) in the case of both sexes. Sites No. 11 and No. 12 are only 6 km distance from each other, even though male morphology was different (Figs 7 & 8).

Searching for body parameters which are responsible for morphological differences, averages of all measured parameters were compared for specimens sampled from the habitat type A and B. In the case of the legs and wings correlation between body parameters and habitat type was accepted only, when LD1 was higher than 0.2 for both right and left appendages (symmetry of the appendages was presumed). In some cases body and habitat parameters showed good correlation at both sexes. Length of the hind leg tarsus, length of the hind leg claw, width of the pronotum and distance between eyes were these parameters (Table 2). Moreover, nine further parameters for females and three for males confirmed correlation between body morphology and habitat type (Table 2).

Comparing body parameters significant differences were found for females ($n = 7$ cases) as well as for males ($n = 9$ cases) regarding to their habitat type (Table 3). All significantly different body parameters were greater in those individuals which were found in habitat type B. This finding is not related to the sex. These result shows that individuals found in habitat type where submerge plant density is low, had higher average values at both sexes in all significantly different body parameters than those found in vegetation rich habitat type. The length of the hind leg claw is especially worthy of note. It was the only body parameter which proved to be significantly greater of the individuals from habitat type B irrespectively of sex.

Certain body parameter differences were related to the sex as well. Body length from the end of the scutellum to the anal siphon and the distance between the eyes was greater at females sampled from habitat type B. In the case of males sampled from habitat type B the tarsus of the middle leg, claws on middle and hind legs and the width of the prothorax were greater.

Table 2. Structure coefficients (i.e. Pearson correlations of the discriminants scores and the body measurements) for those body measurements where the value was higher than 0.2. Bold: structure coefficients are higher than 0.2 at both sexes.

Body parameters	Females		Males	
	right	left	right	left
Paired appendages				
length of the middle leg tibia	0.251	0.303	length of the foreleg coxa	0.201 0.264
length of the hind leg trochanter	0.222	0.224	length of the middle leg tibia	0.428 0.389
length of the hind leg tarsus	0.234	0.291	length of the middle leg claw	0.404 0.372
length of the hind leg claw	0.292	0.283	length of the hind leg tarsus	0.305 0.227
width of the first pair of wings	0.322	0.251	length of the hind leg claw	0.332 0.352
Unpaired appendages				
width of the prothorax	0.209		width of the prothorax	0.283
distance between the eyes	0.319		distance between the eyes	0.237
length of the prothorax	0.339			
width of the prothorax	0.238			
width of the scutellum	0.201			
distance of the frontal edge of the prothorax from the anal siphon basis	0.263			
length of the anal siphon	0.283			
body length	0.292			

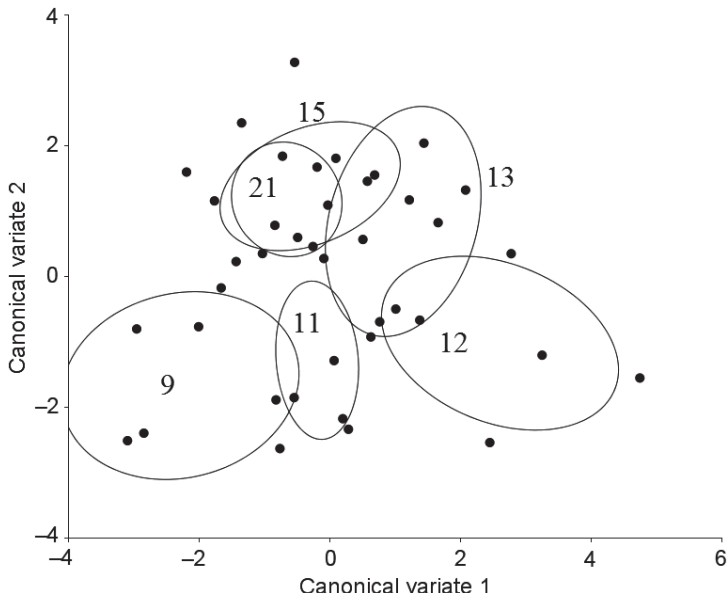


Fig. 7. Canonical variate analysis for males. Only those sampling sites were involved into the analysis where $n \geq 5$. Confidence ellipses for means are shown (probability is 0.9). Numbers refers to localities in Table 1.

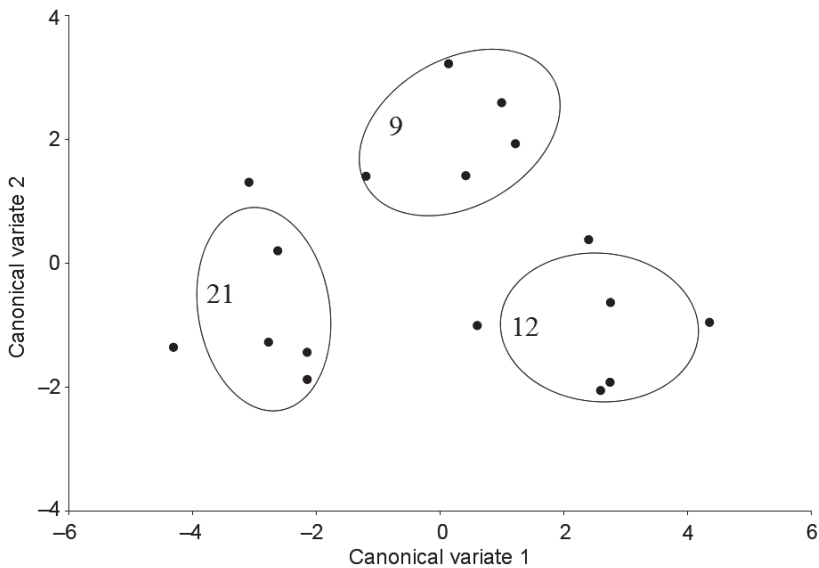


Fig. 8. Canonical variate analysis for females. Only those sampling sites were involved into the analysis where $n \geq 5$. Confidence ellipses for means are shown (probability is 0.9). Numbers refers to localities in Table 1.

Table 3. Body measurements in mm (\pm sd). Only those data are indicated where significant differences were found at least either sex. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Body parameters	Male		Female	
	GroupA	GroupB	GroupA	GroupB
Middle leg (right)				
tarsus	1.41 \pm 0.10	1.51 \pm 0.12***	1.60 \pm 0.13	1.64 \pm 0.12
claw	0.49 \pm 0.07	0.54 \pm 0.07**	0.52 \pm 0.09	0.59 \pm 0.07**
Hind leg (right)				
tarsus	2.00 \pm 0.14	2.09 \pm 0.14*	2.26 \pm 0.21	2.44 \pm 0.15
claw	0.55 \pm 0.07	0.60 \pm 0.01*	0.57 \pm 0.08	0.62 \pm 0.09*
Foreleg (left) coxa	1.30 \pm 0.12	1.37 \pm 0.13*	1.44 \pm 0.13	1.50 \pm 0.15
Middle leg (left)				
tibia	2.77 \pm 0.20	2.78 \pm 0.20	3.02 \pm 0.19	3.12 \pm 0.19*
tarsus	1.41 \pm 0.13	1.50 \pm 0.13**	1.60 \pm 0.13	1.65 \pm 0.14
claw	0.48 \pm 0.07	0.53 \pm 0.08**	0.53 \pm 0.09	0.55 \pm 0.07
Hind leg (left) claw	0.55 \pm 0.08	0.60 \pm 0.07**	0.58 \pm 0.08	0.63 \pm 0.08*
Body length from the end of the scutellum to the anal siphon	10.86 \pm 0.78	10.97 \pm 0.62	12.40 \pm 1.04	12.96 \pm 0.59*
Width of the prothorax	5.05 \pm 0.35	5.23 \pm 0.29*	5.71 \pm 0.51	5.87 \pm 0.27
Distance between the eyes	0.79 \pm 0.11	0.84 \pm 0.11	0.83 \pm 0.11	0.90 \pm 0.12*
Width of the first wing (right)	3.58 \pm 0.28	3.60 \pm 0.25	4.14 \pm 0.39	4.34 \pm 0.23*

DISCUSSION

Habitat quality conditions have crucial effect on presence and size of animal populations (GRIFFEN & DRAKE 2008, ÖRVÖSSY *et al.* 2013, 2014). To our knowledge, no relationship was found between submerse vegetation and body morphology of any water insect species yet. In our study, sampling sites of the water scorpion *N. cinerea* aggregated in two clearly distinct groups. The most important divorcing factor of the sampling sites was the submerse plant density. In addition, some morphological differences of the *N. cinerea* individuals found in the two contrasting habitat types were detected. These results show that *N. cinerea* morphology seems to be influenced by submerse plant density of the habitat.

Long-distance moving activity of the *N. cinerea* is poorly known. It was generally accepted that *N. cinerea* does not have flying ability (HAMILTON 1931, Soós 1963, SOUTHWOOD & LESTON 1959). In contrast, LEMPERT (1997) observed flying individuals from one pond in Germany two subsequent years. That is

why it was supposed in a conservative manner in our study that adult individuals did not move away longer (i.e. one or more kilometre) distance from their sampling place. Consequently, habitat characteristic and adult morphology may be interrelated and it is highly likely that movement of individuals among the sampling sites did not influence the results.

Morphological differences within a single insect species across continental scale were detected several times. It is generally accepted that latitudinal differences may have diverse morphological changes in terrestrial insect species (HODKINSON 2005). However, SHELOMI (2012) found that although there are several examples for the Bergmann's rule in the insect species, this hypothesis should be validated more carefully in the future. In the case of aquatic insects fewer examples are available. JOHANSSON (2003) found that the relationship between body size of the damselfly *Enallagma cyathigerum* (Charpentier, 1840) (Odonata: Coenagrionidae) and latitude is U-shaped in an European scale. Morphology of the midge *Chironomus calligraphus* Goeldi, 1905 (Diptera: Chironomidae) larva (SPIES *et al.* 2002) and the water boatmen *Sigara potamius* Young, 1962 (Heteroptera: Corixidae) (BUCKLEY & YOUNG 2008) show minor regional differences. However, decrease in body size from northern to southern Italy was found in the case of both water bug species *N. cinerea* (TAMANINI 1973) and *Sigara nigrolineata* (Fieber, 1848) (Heteroptera: Corixidae) (TAMANINI 1981).

We did not find such differences. It is most probably because our sampling scale was smaller than those in the mentioned studies.

It was found in this study that *N. cinerea* individuals (both sexes) sampled from the habitat type where submerse plant density was low, have longer hind leg claws. In the case of males, the length of the tarsus and claws of the middle leg proved to be also longer. According to these findings, it is likely that the morphology of the walking legs is important in the habitat adaptation of *N. cinerea*. Such adaptation of the claw was already proven in the case of the cricket *Acheta domesticus* L., 1758 (Orthoptera: Gryllidae) (LEPORE *et al.* 2013) and the water mayfly *Epeorus assimilis* Eaton, 1855 (Ephemeroptera: Heltageniidae) (DITSCHÉ-KURU *et al.* 2012). Shorter claws on the middle leg of the corixid *Arctocorisa carinata* proved to be advantageous for grasping to the bottom (JANSSON & PAJUNEN 1978). Dissimilar function may have the claws on middle and hind legs of *N. cinerea* in comparison to corixids, because *N. cinerea* has walking and not grasping meso- and meta-thoracic legs. However, the clear function of these claws has to be discovered.

Body shape is an essential phenotypic character of the aquatic Ephemeroptera, Plecoptera, Trichoptera and Odonata larvae, but data are limited for many taxa (ORLOFSKE & BAIRD 2014). No such information is available for *N. cinerea*. In our study, individuals sampled from habitat where the submerse vegetation was more or less lacking have greater body parameters in all cases,

if significant difference occurred. Moreover, broader male pronotum, greater body length from the end of the scutellum to the anal siphon and the distance between the eyes shows that females sampled from habitat type B were more robust than those found in habitat type A. It is hypothesized that robustness reflects to greater musculature which may be advantageous in vegetation poor habitat (habitat type B) where the animals are exposed to water flow and probably forced to move more often. This effect may be important, because *N. cinerea* is a sit-and-way predator, which is moving rarely.

The first pair of the *N. cinerea* legs is specialized catching of the prey (HAMILTON 1931). Tactile and chemical stimuli triggered by the prey play primer importance in feeding (ABRAHAM 1943, GREVEN & BRENNER 2007). Foreleg morphology in Belostomatidae, a relative taxon to Nepidae (OHBA *et al.* 2008), as well as in the case of *N. cinerea* (GORB 1995) is relevant to the manner of catching prey. We did not find any significant differences in first leg morphology. Therefore, it is concluded that feeding habit and strategy was not notably different between *N. cinerea* populations according to their habitat type.

Sexual size dimorphism is generally distributed phenomenon in animals. The association between fitness and phenotype differs according to the sex, but detailed understanding the mechanisms is poorly understood (STILLWELL *et al.* 2010). Female larvae of the chironomid *Telmatogeton torrenticola* (Terry, 1913) (Diptera: Chironomidae) were more than twice as large as males and this difference was influenced considerably by the habitat (BENBOW 2008). No such effect was found in our study in spite of the fact that body length of the males and females differed significantly.

Results of this study confirm the importance of the habitat effect, especially submerge plant density, on *N. cinerea* morphology. Body shape and leg morphology showed relationship with habitat characteristics. This may be a sign of phenotypic plasticity, which may one of the explanations of wide-spread distribution of *N. cinerea* in diverse habitats.

*

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