

Microcrustacean diversity in the Gemenc-Béda-Karapanca Floodplains (Danube-Drava National Park, Hungary): rare and alien species

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Abstract. The composition of microcrustacean fauna was investigated in different water bodies of Gemenc-Béda-Karapanca Floodplains with special regard to the distribution of alien and rare taxa. Between 2002 and 2013 101 taxa (57 Cladocera, 27 Copepoda, 17 Ostracoda,) were recorded from the water bodies with differing degrees of connectivity to the main river (eu-, para-, plesio- and paleopotamon). 18 species are reported for the first time from the area of Danube-Drava National Park and among them *Daphnia ambigua*, *Pleuroxus denticulatus* and *Eurytemora velox* are allochthonous species in Hungary. *E. velox* and *P. denticulatus* have persistent populations in the area, but their contribution to floodplain biodiversity is still not significant. *Daphnia ambigua* has only local and temporal populations and its presence is confined to the disconnected side of the floodplain. The abundance of thirty species was very low and their distribution pattern in the floodplain is different. The microcrustacean diversity of the plesiopotamal side arms is remarkable, particularly in the Nyéki-Holt-Danube.

Keywords. Alien species, Cladocera, Copepoda, Ostracoda, species richness, Gemenc-Béda-Karapanca Floodplains.

INTRODUCTION

Floodplains are an important area of biodiversity, providing habitat for endangered or threatened species. Floodplain rivers are disturbance-dominated ecosystems characterized by high levels of habitat diversity and biota adapted to exploit the spatio-temporal heterogeneity (Junk *et al.* 1989, Amoros & Roux 1988, Ward & Stanford 1995). Ecotones, hydrological connectivity, and succession processes play major role in structuring the spatio-temporal heterogeneity leading to the high biodiversity that characterizes floodplain rivers.

The Gemenc-Béda-Karapanca Floodplains of the Danube River (rkm 1497–1440) part of the Danube-Drava National Park (Hungary) represents an exceptional example of river-floodplain systems in Europe with meanders, oxbow lakes, marshlands, and extended hardwood forests. These floodplains are also Natura 2000 areas and

form an UNESCO Biosphere Reserve. This area is the largest active floodplain in Europe with unique natural value (Zinke 1996). It lies completely within the dike system, namely the characteristic hydrological processes of the river floodplain system are not disturbed.

Limited number of studies is dealing with the Cladocera, Copepoda and Ostracoda fauna of this area. The first data was presented by Bothár (1980) describing 18 Cladocera and 10 Copepoda species in the Vén-Danube and in the main arm near Baja. In 1994 Körmendi (2007) recorded 10 Cladocera and 10 Copepoda taxa from different dead arms and temporary pools of Gemenc floodplain. The most comprehensive description of the fauna was published by Forró & Meisch (1998). Their studies revealed 118 crustacean species (Anostraca, Notostraca, Cladocera, Copepoda, Ostracoda, Isopoda, Amphipoda and Mysida) from the Drava region of the Danube-Drava National Park based on collectings between 1995

and 1997. In 1999 Körmendi and Lanszki (2002) recorded 37 Cladocera and 11 Copepoda taxa from various water bodies of Danube-Drava National Park. Between 1997 and 1998 Csányi *et al.* (1998) examined the zooplankton assemblages in the Vén-Danube, Nyéki-Holt-Danube and the main arm near to Baja reporting on 15 zooplankton taxa.

Between 2002 and 2013 detailed investigations were carried out and part of this project was to examine the zooplankton assemblages in water bodies with differing degrees of connectivity to the main river on a near natural temperate river-floodplain system (e.g. Schöll & Kiss 2008, Kiss & Schöll 2009, Kiss *et al.* 2014).

Here we summarize the faunistic results of this long-term study focusing the presence and distribution of rare and alien microcrustacean species and furthermore, the species composition of different water bodies on the floodplain.

MATERIALS AND METHODS

Study area

Covering some 25,000 ha, the Gemenc-Béda-Karapanca Floodplains of the Danube River is situated between rkm 1497 and 1440. In this reach the mean annual discharge is $2400 \text{ m}^3 \text{ s}^{-1}$, with a minimum of $618 \text{ m}^3 \text{ s}^{-1}$ and a maximum of $7940 \text{ m}^3 \text{ s}^{-1}$. The water level is monitored by an official gauge at Baja (rkm 1479; $46^\circ 10,41' \text{ N}$, $18^\circ 55,29' \text{ E}$), which recorded a maximum amplitude of 9 m. In the main arm the slope is about 5 cm km^{-1} , with a velocity of $0.8\text{--}1.2 \text{ m s}^{-1}$ at mean water level. The river starts to overflow into the floodplain above a water level of 500 cm at Baja.

Different riverine functional units can be observed in the study area, thus providing opportunity for simultaneous comparisons. The typology of the water bodies was based on the functional classification of Amoros *et al.* (1987), which depends on the flow velocity of the branches and on the intensity of lateral connectivity between the main channel, the side arms, and the backwaters.

For our investigation the following sites were chosen: 1. *Eupotamon*: the main channel, with permanent flow; bottom composed of stones, gravel and coarse sand; macrophytes are absent. 2. *Parapotamon*: side arms permanently connected to the main channel; bottom composed of gravel mixed with sand and silt; macrophytes are scarce. 3. *Plesiopotamon*: permanent or temporary standing water bodies with no permanent and direct connection to the main arm, connection with the main arm at higher water levels; upstream end is often silted up; the bottom consists of silt and clay, macrophytes could grow densely and highly influenced by the discharge of the river. 4. *Paleopotamon*: former anatomised channels or meanders with no direct connection to the river, slightly influenced by the river discharge, the bottom consists of silt and clay, macrophytes grow very densely (Guti 2001).

A total of 66 sampling sites were selected and divided into four functional groups: eupotamon (3 sites), parapotamon (Vén-Danube, Rezéti-Holt-Danube, 12 sites), plesiopotamon (Grébeci-Holt-Danube, Nyéki-Holt-Danube, Cserta-Danube, Sárkány-fok, Címer-fok, Külső-Béda, Mocskos-Danube, 35 sites), 4. paleopotamon (Riha Oxbow 16 sites) (Fig. 1.). Besides the regularly used sampling sites, additional sites were also selected between 2007 and 2009, during the floods (VDU5; RDU6, 7, 8, 9; GDU6) and among different macrohyte stands in the Mocskos-Danube and Riha Oxbow (19 sites). Sampling was carried out between April 2002 and October 2013, the sampling years were between 2002 and 2004, 2007 and 2009 and 2012 and 2013.

The sampling sites and sampling dates were the following:

Eupotamon

Main arm of the Danube

D1489: 1489 rkm, Érsekcsanád, $\text{N}46^\circ 16,403' \text{ E}18^\circ 54,547'$, in front of the mouth of Grébeci-Holt-Danube.

2002 (08. 04., 03. 07.), 2003 (07. 05., 08. 07., 15. 09. 27. 10.), 2004 (04. 14., 27. 05., 01. 07., 26. 08., 27. 10.), 2007 (23. 05., 11. 09., 25. 09.), 2008 (29. 07.), 2009 (07. 04., 28.

04., 03. 06., 09. 06., 11. 06., 29. 06., 21. 06., 03. 08., 01. 09., 06. 10., 27. 10.)

D1482: Baja (N46°11,412' E18°55,610')

2008 (29. 07.), 2009 (29. 06., 21. 07., 03. 08.)

D1437: 1437 rkm, Mohács, N45°55,967' E18° 46,433', beyond the harbour of the ferry.

2007 (25. 07., 29. 08., 25. 10.), 2008 (18. 03., 10. 06.), 2009 (22. 06., 28. 07.), 2012 (16. 05., 19. 06., 04. 07., 07. 08., 04. 09., 09. 10.), 2013 (26. 06., 12. 10.)

Parapotamon

Vén-Danube (VDU)

5 km long side arm with constant flow. It was the part of the main arm until the interception in 1897-1898.

VDU2 (N46°11.880' E18°55.177'), VDU3 (N46°12.118' E18°53.843'), VDU4 (N46°12.754' E18°53.940'), small periodical inflow: VDU5 (N46°12.346' E18°53.732')

2002 (08. 04., 02. 05., 13. 06., 03. 07., 12. 11.), 2003 (07. 05., 08. 07., 15. 09. 27. 10.), 2004 (04. 14., 27. 05., 01. 07., 26. 08., 27. 10.), 2007 (23. 05., 11. 09., 25. 09.), 2008 (29. 07.), 2009 (29. 06., 21. 07., 03. 08.)

Rezéti-Holt-Danube (RDU)

15 km long side arm, it was the main arm until the interception in 1893-1894.

RDU2 (N46°14.224' E18°53.192'), RDU3.1 (N46°14.767' E18°52.541'), RDU4 (N46°16.015' E18°53.645'), RDU5 (N46°15.599' E18°53.623'), small periodical inflow: RDU6 (N46°16.208' E18°52.671'), RDU7 (N46°16.237' E18°52.373'), RDU9 (N46°13,412' E18°51,967'), stagnant temporary water body: RDU8 (N46°13.950' E18°51.918')

2002 (08. 04., 02. 05., 13. 06., 03. 07., 12. 11.), 2003 (07. 05., 08. 07., 15. 09. 27. 10.), 2004 (04. 14., 27. 05., 01. 07., 26. 08., 27. 10.), 2007 (23. 05., 11. 09., 25. 09.), 2008 (29. 07.), 2009 (29. 06., 21. 07., 03. 08.)

Plesiopotamon

Grébeci-Holt-Danube (GDU)

7 km long side arm, it was the part of the main arm until the interception in 1895-1896.

GDU1 (N46°16.495' E18°54.104'), GDU2 (N46°17.202' E18°52.921'), GDU3 (N46°17.451' E18°55.610'), GDU4 (N46°17.638' E18°53.162'), GDU5 (N46°17.641' E18°53.261'), small temporary inflow: GDU6 (N46°17.682' E18°53.210')

2002 (08. 04., 02. 05., 13. 06., 03. 07., 12. 11.), 2003 (07. 05., 08. 07., 15. 09. 27. 10.), 2004 (04. 14., 27. 05., 01. 07., 26. 08., 27. 10.), 2007 (23. 05., 11. 09., 25. 09.),

Nyéki-Holt-Danube (NYHD)

This strictly protected oxbow is situated in the right side of the Danube (rkm 1479) in the active floodplain. It is a natural cut-off river meander which evolved during the end of the 18th century. The oxbow together with the Cserta-Danube, Sárkány- and Címer-fok form a complex hydrological unit. The threshold level of the surface hydrological connection of NYHD up- and downstream is reached when the water level of the Danube River at rkm 1478.7 (Baja gauge station) is 520 cm and 570 cm, respectively. Upstream it is achieved through Vén-Duna (VDU), Cserta-Duna (CSDU) and Sárkány-fok (SÁF), while downstream – through the Címer-fok (CIF). Its channel is silting up and it has a high macrophyte cover (Ágoston-Szabó *et al.* 2014).

NYHDI (46° 11,642' 18° 50,991'), NYHD2 (46° 11,563' 18° 50,834'), NYHD3 (46° 11,489' 18° 50,937'), NYHD4 (46° 11,573' 18° 51,175'), NYHD5 (46° 11,433' 18° 50,756')

2003 (07. 05., 08. 07., 15. 09.), 2004 (27. 05., 01. 07.), 2009 (07. 04., 28. 04., 03. 06., 09. 06., 11. 06., 29. 06., 21. 06., 03. 08., 01. 09., 06. 10., 27. 10.)

Cserta-Danube (CSDU)

CSDU (N46°11,783' E18°53,053') is a plesiopotamal side arm of the Vén-Danube (VDU). It together with Sárkány- and Címer-fok is part of the so-called fok-system, which are typical section of the local hydrological system. The creation of the fok-system (drainage canals) was the most important human impacts, which changed the hydrological condition of the floodplain (Guti 2001).

CSDU1 (N46°11,541' E18°52,431') CSDU2(N46°11,761' E18°53,121'), CSDU3 (N46°12,133' E18°53,756')

2003 (07. 05., 27. 10.), 2007 (25. 09.)

Sárkány-fok (SÁF)

SÁF (N46°11,816' E18°51,594') is a narrow channel between the NYHD and the CSDU.

2 sampling sites

2003 (07. 05., 08. 07., 15. 09.)

Címer-fok (CIF)

CIF (N46°46,781' E18°50,723') is a narrow channel between the NYHD and the main arm of the Danube. 2 sampling sites

2003 (07. 05.)

Mocskos-Danube (MDU)

This side arm (rkm 1442-1440) is situated in the active floodplain of Béda-Karapanca area. Approximately 3.4 km long, 60 meter wide, with shallow water (average depth: 1.5 m) and very dense macrovegetation. It has a temporary connection with the Danube, the water flowing at 700 cm (gauge of Mohács rkm 1447) at the upper end and at 550 cm at the lower end of the oxbow. The water of MDU only rarely flows (1–5 times per year), and this take place only for short periods at a time (gauge of Mohács 550 cm).

MDU1 (N45°57'24,8" E18°46'24,7"), MDU2 (N45°57'35,3" E18°46'38,2"), MDU4 (N45°57'58,7" E18°46'43,9"), MDU5 (N45°58'06,2" E18°46'37,1"), MDU7 (N45°58'18,3" E18°45'57,1") and further seven sampling points among the submerged macrovegetation near to the regularly used sites.

2009 (22. 06., 28. 07.), 2012 (16. 05., 19. 06., 04. 07., 07. 08., 04. 09., 09. 10.), 2013 (26. 06., 23. 07., 18. 09.)

Külső-Béda (BDU)

It is situated on the right bank of the Danube (N45°55,767' E18°45,420") in the active floodplain of Béda-Karapanca. Its open water area is 4 km long, 90 m wide on average and is about 2.5 m deep. Its upstream junction with main channel of the Danube is at the rkm 1440.5, while the downstream junction, the mouth is at rkm 1437.5 of the Danube. The upstream surface connection of BDU occurs only during high floods, above 630 cm water level of the Danube (at gauge of Mohács rkm 1447) (Ágoston-Szabó *et al.* 2013). 5 sampling sites

2007 (25. 07., 29. 08., 25. 10.), 2008 (18. 03., 10. 06.)

Paleopotamon

Riha Oxbow (RIH)

This oxbow is located on the protected side of the floodplain and it has no connection with the main channel. It is 4.5 km long and 80 m wide. The average water depth is approximately 1-1.5 m. It is a strictly protected nature reserve areas covered by dense macrovegetation.

RIH1 (N46°00'08,1" E18°44'33,9"), RIH21 (N46°00'44,6" E18°45'10,3"), RIH22 (N46°00'35,4" E18°46'14,2"), RIH3 (N46°00'09,6" E18°46'30,9") and further 12 sampling points among the submerged macrovegetation near to the regularly used sites.

2012 (16. 05., 19. 06., 04. 07., 07. 08., 04. 09., 09. 10.), 2013 (26. 06., 23. 07., 18. 09.)

Collecting and identification

Microcrustaceans were collected with plankton net (mesh size 70 µm, N= 1) by filtering 10 X 10 L of water from the main arm and 5 X 10 L of water from the side arms, then preserved in 4% formalin. The three examined groups of crustaceans were enumerated by using inverted microscopy and identified to species level. Microcrustacean abundance, including copepodids, was evaluated by enumerating individuals in the whole sample. Gulyás & Forró (1999, 2001), Meisch (2000) and the nomenclature of Dussart (1967, 1969) were used for species identification.

RESULTS AND DISCUSSION

Faunistic results

Between 2002 and 2013 101 taxa (57 Cladocera, 27 Copepoda, 17 Ostracoda,) were recorded (Appendix 1) and 18 species reported which have not been mentioned earlier from the area of Duna-Drava National Park. These are the followings: Cladocera: *Alona intermedia* Sars, 1862; *Bosmina longispina* Leydig, 1860; *Ceriodaphnia dubia* Richard, 1894; *Chydorus gibbus* Sars, 1890; *Daphnia ambigua* Scourfield, 1946; *Dunhevedia crassa* King, 1853; *Holopedium gibberum* Zaddach, 1855; *Pleuroxus denticulatus* Birge, 1879; Copepoda: *Canthocamptus staphylinus* (Jurine, 1820); *Cyclops insignis* Claus, 1857; *Cyclops scutifer* Sars, 1863; *Eurytemora velox* (Lilljeborg, 1853); *Paracyclops affinis* (Sars, 1863); Ostracoda: *Bradleycypris obliqua* (Brady, 1868), *Bradleystrandesia reticulata* (Zaddach, 1844); *Cypris pubera* O. F. M., 1776; *Notodromas monacha* (O. F. Müller, 1776); *Paracandona euplectella* (Robertson, 1889).

Most of the collected microcrustacean species are widespread and characteristic of the fauna of the littoral zone in floodplain water bodies and lakes. The number of the detected taxa was significantly higher than the published results of pre

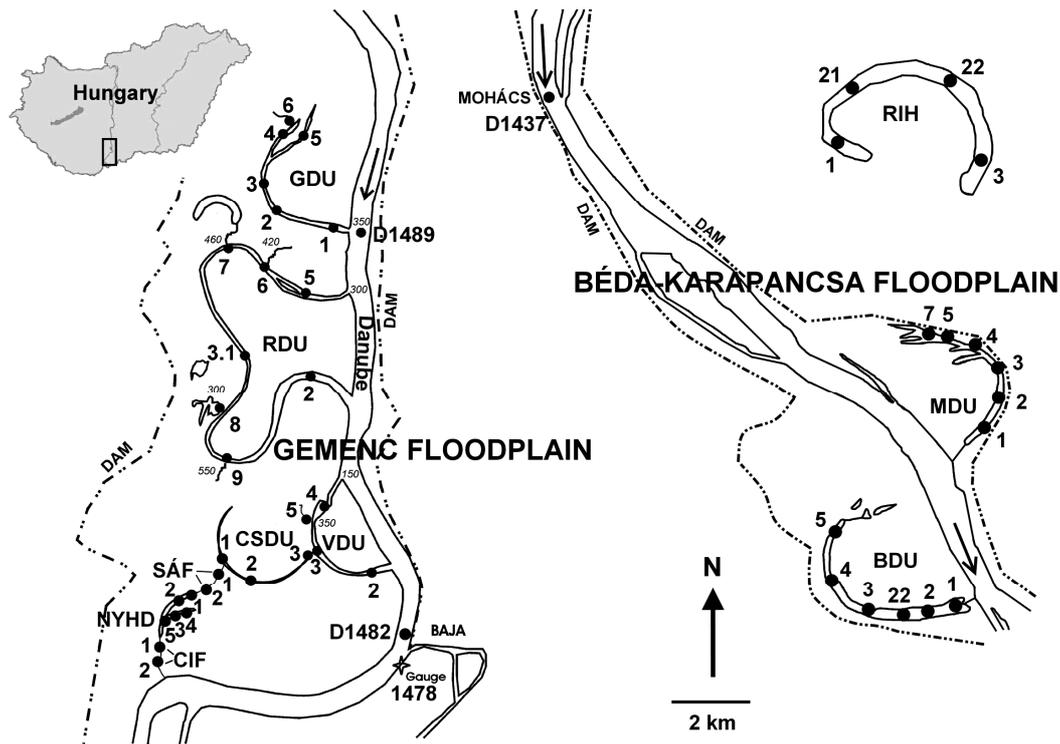


Figure 1. Sampling sites on the Gemenc-Béda-Karapanca Floodplains (Gemenc floodplain: Grébeci-Holt-Danube (GDU), Rezéti-Holt-Danube (RDU), Vén-Danube (VDU), Cserta-Danube (CSDU), Sárkány-fok (SÁF), Nyéki-Holt-Danube (NYHD), Cimer-fok (CIF), Béda-Karapanca floodplain: Riha oxbow (RIH), Mocskos-Danube (MDU), Külső-Béda (BDU))

vious studies (Bothár 1980: 28 taxa; Csányi *et al.* 1998: 15; Körmendi & Lanszki 2002: 47; Körmendi 2007: 16) with the exception of the investigation of Forró & Meisch (1998) (111 taxa), but in our studies the area of sampling was more extensive and the duration of the survey was longer than any other studies. All of the species reported by Csányi *et al.* (1998) and Körmendi (2007) were also recorded in our studies. 27 species in the study of Bothár (1980), 43 in Körmendi and Lanszki (2002), as well as 73 taxa in the investigation of Forró and Meisch (1998) also occurred between 2002 and 2013.

There were significant differences in the species richness between water bodies with differing degrees of connectivity with the Danube (Appendix 1). Species richness was the highest in the plesiopotamon, which has no permanent and direct connection to the main arm. Among the newly detected species, *Daphnia ambigua*,

Pleuroxus denticulatus and *Eurytemora velox* are alien or non-native (allochthonous) species in Hungary. The abundance of thirty species was irrelevant; in these species less than 10 individuals were collected between 2002 and 2013. These were regarded as rare species in Gemenc-Béda-Karapanca Floodplains.

Alien species

The copepod genus *Eurytemora* occupies a wide range of habitat types throughout the Northern Hemisphere, with among the broadest salinity ranges of any known copepod. *Eurytemora velox*, as originally salt water species is widely distributed in the brackish waters from the Arctic Ocean and the Baltic Sea shore to South-eastern Europe, the Sea of Azov, and the Caspian Sea. This euryhaline species migrated from the estuaries of the North Sea upstream of many rivers (Tollinger 1911) and from the Black Sea

upstream in the Danube River (Gaviria & Forró 2000). In the Middle Danube Basin this species was collected for the first time in Hungary in 1991 (Forró & Gulyás 1992), also in Slovakia (Vranovský 1994) and Austria (Gaviria & Forró, 2000) in the very same year. In the last twenty years *E. velox* was presumably spread in the whole Hungarian section of the Danube and in many freshwater habitats of Hungary also. For example, in the Lake Fertő (the westernmost and largest steppe lake in Eurasia, situated on the Hungarian-Austrian border) this species showed up for the first time in 2009 then spread gradually and in 2012 a total of 492 specimens were collected (Kiss *et al.* 2014).

In the area of the Danube-Drava National Park the presence of *E. velox* was recorded in 2002 (Kiss & Schöll 2009), the previous faunistic works (Körmendi 2007, Körmendi & Lanszki 2002, Forró & Meisch 1998) did not mention this species. In our investigation altogether 622 individuals of *E. velox* were collected between 2002 and 2013. Most of the individuals were in the plesiopotamal Mocskos-Danube (297 individuals) and the distribution of this calanoid differed significantly between the examined water bodies (Fig. 2. A). Larger part of the collected specimens occurred in the plesiopotamal wetlands which are situated close to the main arm and often connected with the Danube. Similarly to our observation in Lake Fertő (Kiss *et al.* 2014), the number of the collected individuals differed year by year and there was a significant increase from 2009 (Fig. 2. B).

In the sampled habitats this calanoid often coexisted with other calanoids, *Eudiaptomus vulgaris* and/or *Eudiaptomus gracilis*. The number of *E. velox* was significantly higher than the two *Eudiaptomus* species (Fig. 3.) similarly to the observation of Vad *et al.* (2012). Opposite to other observations, e.g. soda pan in western Hungary (Horváth & Boros 2010) or two artificial lakes in the region of the North Hungarian Mountains (Vad *et al.* 2012), *E. velox* is still not a dominant member of Copepoda assemblages in Gemenc-Béda-Karapanca Floodplain. In the area

of Szigetköz (Northwestern Hungary, 1850–1793 rkm) the abundance of this species was also not significant at the monitoring sites of Szigetköz Monitoring Network between 1999 and 2013. During the fourteen years of monitoring only 155 specimens were collected from the three section of Szigetköz (main arm connected and reconnected floodplain).

Pleuroxus denticulatus is also an allochthonous species in the Middle Danube Basin. It was described from North America (Birge 1879) and its range is restricted to the northern hemisphere (Frey 1993). This North-American Cladocera occurs in Europe since the 1970s. This species is a new invader from Western to Central Europe and its occurrence in the Danube probably corresponds with the opening of the Rhine-Main-Danube Canal (Hudec & Illyová 1998). The first occurrence of *P. denticulatus* in the Hungarian section of the main channel was reported in 1992 at rkm1669 (Bothár 1994), since then it has been spread in the main arm (Gulyás 1995, Kiss & Schöll 2009, Vadadi *et al.* 2009). Similar to *E. velox*, *P. denticulatus* was also not revealed by the previous studies from the Danube-Drava National Park (Körmendi 2007, Körmendi & Lanszki 2002, Forró & Meisch 1998, Csányi *et al.* 1998). In the study area, *P. denticulatus* was firstly collected in 2003 from the Cserta-Danube and Sárkány-fok, then it was spread the whole active floodplain, but in the protected side of the floodplain this species does not occur yet (Fig. 2. C).

According to our result, this species was spread in the whole river-floodplain system and it supposedly has permanent population in the floodplain, but its density was very low, only forty specimens were collected between 2003 and 2012. Similar trend can be observed in the area of Szigetköz, where only 67 individuals were collected between 1999 and 2013 (A. Kiss unpublished result). This alien cladoceran was mostly found in the littoral zone, between submerged or emergent macrophytes. It was usually found together with typical littoral cladocerans, especially *Pleuroxus aduncus*, *P. truncatus*, similar to the observations of Hudec and Illyová (1998) and Vad *et al.* (2012).

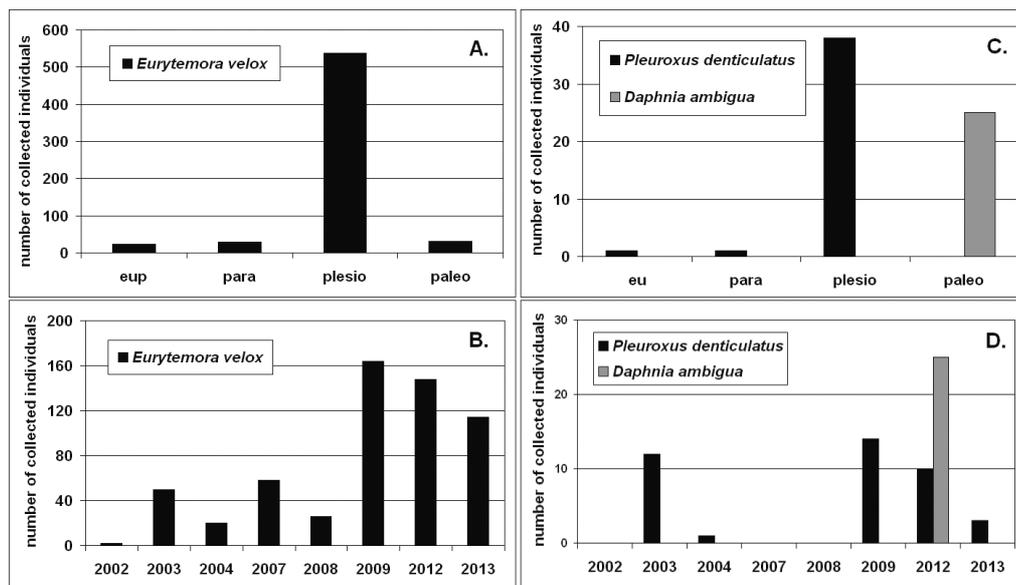


Figure 2. The distribution of the three alien species in the study area between 2002 and 2013 (A and B = *Eurytemora velox*, C and D = *Daphnia ambigua* and *Pleuroxus denticulatus*).

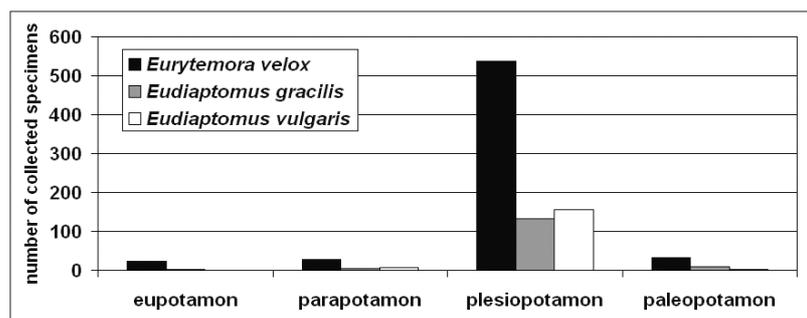


Figure 3. Distribution of the three Calanoida species in the study area between 2002 and 2013.

Daphnia ambigua, one of the most broadly distributed members of its genus, occurs in Europe as well as in North and South America (Herbert *et al.* 2003). This species is native to the temperate regions of North America and it was introduced to Europe where it is now broadly distributed (Maier 1996). Similarly to *Pleuroxus denticulatus*, it has been spreading from Western to Central Europe in the last few decades (Vranovský & Terek 1996). In Hungary *D. ambigua* is a rare species, their presence was confirmed especially from the Danube (Gulyás & Forró 1999, Kiss & Schöll 2009), but Vad *et al.* (2012) found this species in an artificial lake in the region of the North Hungarian Mountains as

well. In our studies *D. ambigua* was found only at two sampling sites of the paleopotamal Riha Ox-bow, in May 2012. Only 25 individuals were collected together with *Daphnia cucullata*, *D. longispina*, *Bosmina longirostris*, *Ceriodaphnia pulchella*, *Chydorus sphaericus*, *Eurytemora velox*, and seven other species. In the area of Szigetköz (northwest Hungary) between 1999 and 2013, only one individual of *D. ambigua* was found in 2006, in the Schisler-dead arm (A. Kiss unpublished result).

It is obvious that *Eurytemora velox* and *Pleuroxus denticulatus* have a permanent population in Gemenc-Béda-Karapanca Floodplains,

but according to our results *D. ambigua* is still not permanent member of the fauna and its local and occasional presence could be correlated with bird-mediated dispersal (Riha Oxbow is an important area used by migratory birds).

Species of zooplankton, especially cladocerans can easily spread with passive transport (via wind, water or birds), mainly due to their ability to create resting eggs (Havel *et al.* 1995). The role of human-mediated vectors is also noteworthy especially for species dispersal across geographical barriers and into large aquatic ecosystems. Diapausing stages facilitate species survival during movement across geographical barriers under extreme conditions, such as in ballast tanks of ships (MacIsaac *et al.* 2001).

Rare species

The abundance of thirty species (13 Cladocera, 10 Copepoda, 7 Ostracoda) is insignificant, less than ten individuals were collected between 2002 and 2013. In case of nine species only one individual was found in the whole period of sampling. Twenty-two species were mentioned by earlier works (Bothár 1980, Forró & Meisch 1998, Körmendi & Lanszki 2002, Körmendi 2007), accordingly these species are supposedly permanent members of the local fauna.

Most of the rare species were distributed in the connected floodplain, in the plesiopotamon and especially in the Nyéki-Holt-Danube (Fig. 4. A-C). Among the sampling years, the number of rare species was the highest in 2003 and 2009. This result could be subsequent upon our sampling program and the hydrological events. In 2003 all of the potamon-types were investigated at the same time and extensive macrovegetation developed in many places in the floodplain because the water level was low in the main arm. In 2009, a detailed study was launched in the Nyéki-Holt-Danube, which is the most diverse area in Gemenc-Béda-Karapanca-Floodplains.

Among the rare species, *Holopedium gibberum*, *Ceriodaphnia dubia*, *Cyclops insignis*, *Cypriis pubera*, *Paracyclops affinis*, *Bradleystrandesia*

reticulata, *Notodromas monacha* and *Paracandona euplectella* are new species for the Danube-Drava National Park.

Holopedium gibberum is one of the most infrequent microcrustacean species in Hungary being reported only from the Danube (Gulyás & Forró 1998). In our study, three individuals of *Holopedium* were collected in September 2007 from the Rezéti-Holt-Danube (Kiss & Schöll 2009). In the beginning of September 2007 there was an extreme water level (797 cm, Baja gauge) in the flooding period and our sampling was in the receding period when the mixing floodplain waters start to flow back toward the main arm. This holarctic species prefers mainly cool, oligotrophic, soft-water lakes with low pH (Balcer *et al.* 1984) and it is noteworthy that the resting eggs of *Holopedium* are poorly adapted for transfers among habitats (Cox & Hebert 2001). Supposedly we found a small temporary population of *Holopedium*, which was transported by the flood.

Similarly to *Holopedium*, the two individuals of *Cyclops insignis* were detected in September 2007 as well in the receding period of the flood. Both species prefer mainly small standing water habitats and lower water temperature. The carnivorous cladoceran, *Polyphemus pediculus* was also reported from many localities of Hungary (Gulyás & Forró 1999), but only eight specimens was collected from Nyéki-Holt-Danube. Among the former works, it was only reported by Forró and Meisch (1998) from two localities of Drava region.

Out of the seven rare ostracods three (*Bradleystrandesia reticulata*, *Candona weltneri*, *Paracandona euplectella*) were collected in the Nyéki-Holt-Danube in 2003, when the water level of the oxbow was extremely low. These species prefer small water bodies with swampy or boggy bottom. The neustonic ostracod, *Notodromas monacha* is widely distributed across the Holarctic region and common everywhere in suitable habitats (Meisch 2000). In Hungary it is recorded from many localities and sometimes was multitudinous in the plankton (e.g. Kiss 2007). Curiously, the only collected specimen of *Notodromas* occurred in the main arm.

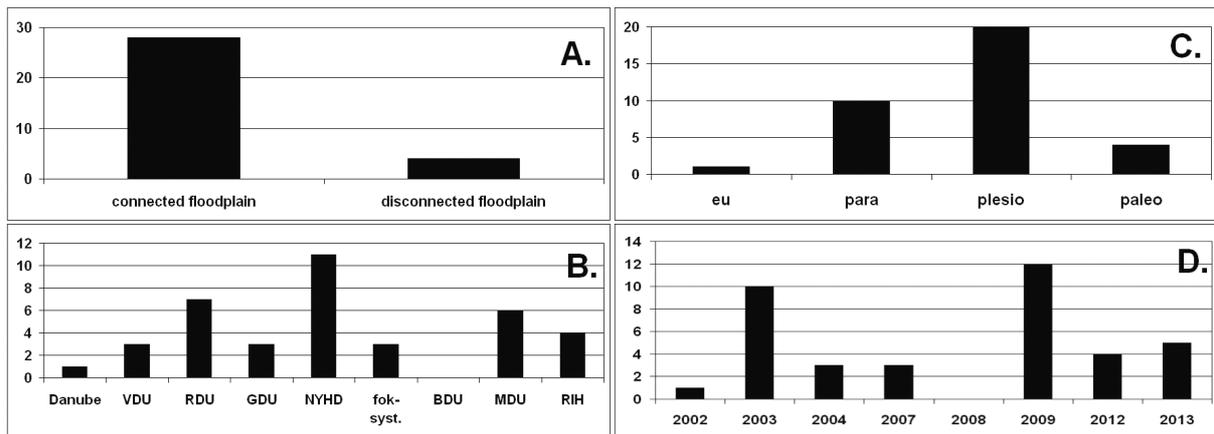


Figure 4. Species richness of the rare species in the study area. A = the number of taxa in the connected (eu-, para- and plesio-potamon) and in the disconnected (paleopotamon) floodplain, B = the number of taxa in the sampling sites, C = the number of taxa the different functional units, D = The occurrence of rare species in the different sampling years.

In our studies, the scarce occurrence of some taxa, e.g. benthic *Paracyclops* spp., *Ectocyclops phaleratus*, Harpacticoida or bottom-dwelling ostracods (Candonidae, Limnocythere) is evident because we did not collect from the benthos.

Microcrustacean species richness in water bodies with differing degrees of connectivity with the main arm

The species richness, the average, and maximum number of taxa were different in the studied water bodies and were the highest in the plesio-potamon (Fig. 5).

36 taxa (N = 54) were collected from the eupotamon, the most frequent species were *Bosmina longirostris*, *Chydorus sphaericus* and *Acanthocyclops robustus* which are typical for the Hungarian section of Danube. The average number of taxa was 3.85 and the differences between the three sampling sites of the main arm were irrelevant.

In the parapotamon the species richness (57 taxa, N = 143) and the number of rare taxa (10) increased and 9 taxa occurred in this functional unit alone. Among these species, *Holopedium gibberum* and *Diaphanosoma mongolianum* were found in the conjunctive water bodies in the

receding period of the flood. These water bodies are small channels, branching out from side arms, hydrologically interconnecting them to the floodplain (Schöll *et al.* 2012). Compare to the main arm, there was no difference in the average number of taxa, 9 but the maximum number of taxa per sample (10) was higher than the eupotamon. The most significant species were the characteristic species of the main arm and *Thermocyclops* spp., but the tycho-planktonic and phytophilous taxa were also occurred.

The species richness (83 taxa: 45 Cladocera, 26 Copepoda, 12 Ostracoda) and the number of rare taxa (20), the average (7.23) as well as the maximum (22) number of taxa were the highest in the plesio-potamon. 28 taxa reported from the plesio-potamon alone and the number of tycho-planktonic and phytophilous taxa was significant. There were significant differences in the species richness between the studied plesio-potamal side arms. In the Gemenc-Béda-Karapanca Floodplains, Nyéki-Holt-Danube was proved to significantly important area of microcrustacean diversity. Despite of the relatively small number of samples (N = 50), the species richness (60 taxa) and the number of rare taxa (11) were the highest in the area. The species richness was also notably in the fok-system (41 taxa, N = 13), but contrary to this, only 22 taxa were detected in the Külső-Béda (22).

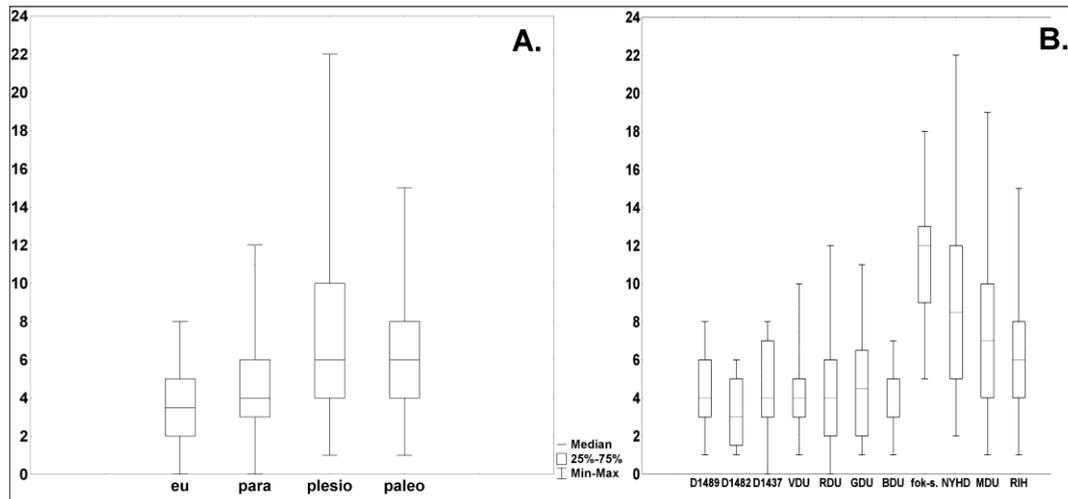


Figure 5. The species richness of microcrustaceans in the different potamon-types (A) and in the different sampling sites (B) (see text for further explanation.)

In the paleopotamon (N = 72) 43 taxa were collected and average (6.23) and maximum number of species (15) as well as the number of rare taxa (4) decreased compare to the significant part of the plesiotamonal side arms. The high proportion of tychoplanktonic and phytophilous taxa in the assemblages is obvious. Many works (e.g. Tockner *et al.* 1998) published positive correlation between the species richness and the degree of connectivity between the main channel and the backwaters, but according to our observation the species diversity of microcrustaceans was the highest in the plesiotamonal and not in the disconnected floodplain.

CONCLUSION

Between 2002 and 2013 101 taxa were recorded in the area of Gemenc-Béda-Karapanca Floodplains and 18 species proved to be new for the region. The species richness and composition of the fauna were different in the examined floodplain water bodies and the number of microcrustacean species was most significant in the plesiotamonal. The fauna of the plesiotamonal Nyéki-Holt-Duna is noticeably diverse and this oxbow is a “diversity hotspot” in the floodplain. This study proved the presence of *Daphnia ambigua*, *Pleuroxus denticulatus* and *Eurytemora velox* and confirmed the expansion of these non-native species in the floodplain. *E.*

velox and *P. denticulatus* have persistent populations in the area, but their contribution to floodplain biodiversity is still not significant. *Daphnia ambigua* has only local and temporal populations and its presence is confined to the disconnected side of the floodplain.

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Appendix 1. List of Cladocera, Copepoda and Cladocera taxa collected in Gemenc-Béda-Karapanca Floodplains between 2002 and 2013

	eup.	parapotamon		plesiototamon					paleop.
	Danube	RDU	VDU	GDU	NYHD	MDU	BDU	fok-syst.	RIH
Number of samples	54	78	65	60	50	95	47	13	72
CLADOCERA									
<i>Acroperus harpae</i> (Baird, 1834)	X				X	X		X	X
<i>Alona affinis</i> (Leydig, 1860)		X							X
<i>Alona costata</i> Sars, 1862	X	X	X	X	X	X		X	X
<i>Alona guttata</i> Sars, 1862	X	X		X		X	X		
<i>Alona intermedia</i> Sars, 1862					X	X			
<i>Alona quadrangularis</i> (O. F. M., 1785)	X	X	X			X		X	X
<i>Alona rectangula</i> Sars, 1862	X				X		X		
<i>Alonella excisa</i> (Fischer, 1854)					X	X		X	X
<i>Alonella nana</i> (Baird, 1850)		X	X		X			X	X
<i>Bosmina coregoni</i> Baird, 1857	X	X	X	X		X			
<i>Bosmina longirostris</i> (O. F. M., 1785)	X	X	X	X	X	X	X	X	X
<i>Bosmina longispina</i> Leydig, 1860			X			X			
<i>Camptocercus rectirostris</i> Schoedler, 1862					X				X
<i>Ceriodaphnia dubia</i> Richard, 1894									X
<i>Ceriodaphnia laticaudata</i> P. E. M., 1867	X						X	X	
<i>Ceriodaphnia megops</i> Sars, 1862	X				X	X		X	X
<i>Ceriodaphnia pulchella</i> Sars, 1862	X	X			X	X			X
<i>Ceriodaphnia quadrangula</i> (O.F.M., 1785)	X		X	X	X	X		X	X
<i>Ceriodaphnia reticulata</i> (Jurine, 1820)				X	X		X	X	X
<i>Chydorus gibbus</i> Sars, 1890					X				
<i>Chydorus sphaericus</i> (O. F. M., 1776)	X	X	X	X	X	X	X	X	X
<i>Daphnia ambigua</i> Scourfield, 1946									X
<i>Daphnia cucullata</i> Sars, 1862	X	X	X	X	X	X	X		X
<i>Daphnia hyalina</i> Leydig, 1860			X						
<i>Daphnia longispina</i> O. F. M., 1785	X	X		X			X	X	X
<i>Daphnia obtusa</i> Kurz, 1874						X			
<i>Daphnia pulex</i> Leydig, 1860					X				
<i>Diaphanosoma brachyurum</i> (Liévin, 1848)	X	X	X	X		X	X		X
<i>Diaphanosoma mongolianum</i> Uéno, 1938		X							
<i>Disparalona rostrata</i> (Koch, 1841)	X	X	X	X			X	X	X
<i>Dunhevedia crassa</i> King, 1853		X			X				
<i>Eurycercus lamellatus</i> (O. F. M., 1785)					X				
<i>Graptoleberis testudinaria</i> (Fischer, 1848)	X			X	X	X			X
<i>Holopedium gibberum</i> Zaddach, 1855		X							
<i>Iliocryptus agilis</i> Kurz, 1878	X	X	X	X	X		X		
<i>Iliocryptus sordidus</i> (Liévin, 1848)			X						

	Danube	RDU	VDU	GDU	NYHD	MDU	BDU	fok-syst.	RIH
<i>Leydigia leydigi</i> (Schoedler, 1863)			X						
<i>Macrothrix hirsuticornis</i> Norm. et Br., 1867	X	X	X	X					
<i>Macrothrix laticornis</i> (Fischer, 1848)		X	X						X
<i>Moina brachiata</i> (Jurine, 1820)	X	X	X	X	X	X	X		X
<i>Moina macrocopa</i> (Straus, 1820)					X				
<i>Moina micrura</i> Kurz, 1874						X			
<i>Monospilus dispar</i> Sars, 1862			X						
<i>Oxyurella tenuicaudis</i> (Sars, 1862)					X				
<i>Pleuroxus aduncus</i> (Jurine, 1820)	X	X	X	X	X	X		X	X
<i>Pleuroxus denticulatus</i> Birge, 1879	X		X		X	X	X	X	
<i>Pleuroxus laevis</i> Sars, 1862					X	X			
<i>Pleuroxus truncatus</i> (O. F. M., 1785)		X	X	X	X	X		X	X
<i>Pleuroxus uncinatus</i> Baird, 1850		X							
<i>Polyphemus pediculus</i> (Linné, 1761)					X				
<i>Pseudochydorus globosus</i> (Baird, 1843)						X			
<i>Scapholeberis mucronata</i> (O. F. M., 1785)	X	X	X	X	X	X	X	X	X
<i>Scapholeberis rammneri</i> Dum. & P. 1983		X				X			X
<i>Sida crystallina</i> (O. F. M., 1776)	X	X	X		X	X			X
<i>Simocephalus serrulatus</i> (Koch, 1841)					X				
<i>Simocephalus vetulus</i> (O. F. M., 1776)	X	X	X	X	X	X		X	X
<i>Tretocephala ambigua</i> (Lilljeborg, 1900)									X
COPEPODA									
<i>Acanthocyclops robustus</i> (Sars, 1863)	X	X	X	X	X	X	X	X	X
<i>Canthocamptus staphylinus</i> (Jurine, 1820)	X	X		X				X	
<i>Cyclops insignis</i> Claus, 1857		X		X	X				
<i>Cyclops scutifer</i> Sars, 1863					X				
<i>Cyclops strenuus</i> Fischer, 1851		X	X	X	X	X		X	
<i>Cyclops vicinus</i> Uljanin, 1875	X	X	X	X	X	X	X	X	X
<i>Diacyclops bicuspidatus</i> (Claus, 1857)			X	X	X				
<i>Ectocyclops phaleratus</i> (Koch, 1838)		X						X	
<i>Eucyclops macruroides</i> (Lilljeborg, 1901)									
<i>Eucyclops macrurus</i> (Sars, 1863)			X	X		X			
<i>Eucyclops serrulatus</i> (Fischer, 1851)	X	X	X	X	X	X	X	X	X
<i>Eucyclops speratus</i> (Lilljeborg, 1901)						X			
<i>Eudiaptomus gracilis</i> (Sars, 1863)	X	X	X	X	X	X	X		
<i>Eudiaptomus vulgaris</i> (Schmeil, 1896)		X			X				X
<i>Eurytemora velox</i> (Lilljeborg, 1853)	X	X	X	X	X	X	X	X	X
<i>Macrocyclus albidus</i> (Jurine, 1820)					X	X		X	X
<i>Macrocyclus distinctus</i> (Richard, 1887)						X			
<i>Macrocyclus fuscus</i> (Jurine, 1820)						X		X	
<i>Megacyclops viridis</i> (Jurine, 1820)			X	X	X	X		X	X
<i>Mesocyclus leuckarti</i> (Claus, 1857)	X	X	X	X	X	X		X	X

	Danube	RDU	VDU	GDU	NYHD	MDU	BDU	fok-syst.	RIH
<i>Paracyclops affinis</i> (Sars, 1863)					X			X	
<i>Paracyclops fimbriatus</i> (Fischer, 1853)	X	X							
<i>Paracyclops poppei</i> (Rehberg, 1880)					X				
<i>Thermocyclops dybowskii</i> (Lande, 1890)				X			X		
<i>Thermocyclops crassus</i> (Fischer, 1853)	X	X	X	X	X	X		X	X
<i>Thermocyclops oithonoides</i> (Sars, 1863)	X	X	X	X	X		X	X	
OSTRACODA									
<i>Bradleycypris obliqua</i> (Brady, 1868)								X	
<i>Bradleystrandesia reticulata</i> (Zaddach, 1844)					X			X	
<i>Candona weltneri</i> Hartwig, 1899					X				
<i>Candona</i> sp. (juv.)				X	X	X		X	
<i>Cyclocypris laevis</i> (O. F. M., 1776)		X							
<i>Cyclocypris ovum</i> (Jurine, 1820)		X	X		X	X			X
<i>Cypria ophthalmica</i> (Jurine, 1820)		X			X	X	X	X	X
<i>Cypris pubera</i> O. F. M., 1776		X		X					
<i>Cypridopsis vidua</i> (O. F. Müller, 1776)			X	X	X	X		X	X
<i>Dolerocypris fasciata</i> (O. F. Müller, 1776)					X				
<i>Limnocythere inopinata</i> (Baird, 1843)		X							
<i>Notodromas monacha</i> (O. F. Müller, 1776)	X								
<i>Paracandona euplectella</i> (Robertson, 1889)					X				
<i>Physocypris kraepelini</i> G. W. Müller, 1903		X		X	X			X	
<i>Pseudocandona compressa</i> (Koch, 1838)								X	
<i>Pseudocandona</i> sp. (juv.)									X
Ostracoda sp. (juv.)									X
Number of Taxa:	36	47	39	38	60	46	22	41	43