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An Invasion Report of The New Zealand Mud Snail, *Potamopyrgus antipodarum* (Gray, 1843) in Turkish Freshwaters: Delice River and Kocabaş Stream

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ABSTRACT

This study is combined the data from two different studies that carried out different regions and time, presenting some information on the population structure (dominance, local distribution etc.) of *Potamopyrgus antipodarum* (Gray, 1843). According to our data, this species was found in the four different localities in the Delice River with various population densities. However, only of small population was found in the Kocabaş Stream. This species was the second dominant species in the Delice River with 31.43 % after *Physella acuta* (Draparnaud, 1805) (46.88%). On the other hand, the species was not reached noticeable aggregates in the Kocabaş Stream. In this paper, supporting factors that paving the way *P. antipodarum* invasion are discussed for the study area.

Keywords: *Potamopyrgus antipodarum*, invasive population, Delice River, Kocabaş Stream, Turkey

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Türkiye içsularında Yeni Zelanda Çamur Salyangozu, *Potamopyrgus antipodarum* (Gray, 1843)'un bir istila raporu: Delice Nehri ve Kocabaş Çayı

Öz: İki farklı bölgede ve zamanda yürütülen çalışmalardan elde edilen verileri kapsayan bu çalışma, *Potamopyrgus antipodarum* (Gray, 1843)'un popülasyon yapısı ile ilgili bazı verileri (baskınlık, bölgedeki dağılımı gibi) sunmaktadır. Verilerimize göre, Delice Nehri'nde *P. antipodarum* dört farklı noktada ve farklı populasyon yoğunluklarında tespit edilmiştir. Ancak Kocabaş Çayı'nda sadece küçük bir populasyonun varlığına rastlanmıştır. Bu tür % 31,43 değeri ile Delice Nehri'nde *Physella acuta* (Draparnaud, 1805)'dan (% 46,88) sonra ikinci en baskın türdür. Diğer taraftan, bu tür Kocabaş Çayı'nda çok yüksek sayıda bir popülasyona sahip değildir. Bu makalede, *P. antipodarum*'un istilasını destekleyen faktörler tartışılmıştır.

Anahtar kelimeler: *Potamopyrgus antipodarum*, istilacı populasyon, Delice Nehri, Kocabaş Çayı, Türkiye

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Introduction

The New Zealand mud snail, *Potamopyrgus antipodarum* (Gray, 1843), is a truncatelloidean gastropod that can be able to tolerate a wide range of abiotic conditions from coastal estuaries to freshwater ecosystems (Gérard et al. 2003). It is known as an invasive worldwide that the current expansion comprises several continents including Europe, mainland Australia and Tasmania (Ponder 1988) and North America (Bowler 1991).

According to Ponder (1988), introduction of this species date back to 19th century in southern Australia, Tasmania and Europe, then the species has been reported in North America in 1987 (Bowler 1991), Japan (Shimada and Urabe 2003), and more recently in Canada (Davidson et al. 2008). Shell remains of the species have also been found in Lebanon and Iraq (Naser and Son 2009). In Turkey, occurrence of *P. antipodarum* has been known from various freshwater ecosystems and only one coastal

marine area in the western and southern Anatolia since 1980 (Bilgin 1980; Ustaoğlu et al. 2001a, b; Ustaoğlu et al. 2003; Özbek et al. 2004; Kalyoncu et al. 2008; Kılıçarslan and Özbek 2010; Yıldırım et al. 2006; Kebapçı and Yıldırım 2010; Gürlek 2015; Odabaşı and Arslan 2015). Although, its global spread and high infestation rate, all the documentations rely on several shells or specimens and the present records are not related with its population and invasion status on their habitats in Turkey. In this study, we have combined the data sets of two different studies carried out in different running waters: Delice (a branch of the River Kızılırmak) and Kocabaş (running water located in Biga Peninsula), which are located in central and north-western Anatolia, respectively. This study aimed to evaluate the mollusc fauna and demonstrate the population structures of *P. antipodarum* inhabiting in these streams, we also evaluated the invasive characteristics of this species in studied areas.

Materials and Methods

Study Area

The first study area is Delice River that is one of the major tributaries of the Kızılırmak River which is the longest running water across Turkey. The Kızılırmak River flows for a total of 1355 km, rising from Eastern Anatolia and flows into the Black Sea. The Delice River, one of the main tributaries of the Kızılırmak River, flows along 430 km with a high flow rate approximately 30352 m^3/s annually. It has many small tributaries while passing through the Çankırı, Yozgat, Kırşehir and Kırıkkale cities before the joining to the Kızılırmak River (Gül and Yılmaz 2002). Samplings were carried out monthly between July 2007 and August 2008 in the preselected sampling sites in Delice River.

On the other hand, the second study area is Kocabaş Stream (also called as Biga Stream) that rising from the extension of the Kaz Mountain, the ancient name is known as Mount Ida, flows into the Sea of Marmara at Dardanelles. It is one of the most important watercourses in the Biga Peninsula with an 80 km in length and 30 m^3/s annual flow rate. Seasonal samplings were carried out between May 2012 and November 2013 at two sites located both at the upper and lower regions of the dam lake in the Kocabaş Stream (Table 1).

Table 1. Species Content of the freshwater Mollusca in the study area both Delice River and Kocabaş Stream. Legends: St.: Sampling Station, S: Status, N: Native, NC: Non-Native – Cosmopolitan.

	Delice River										Kocabaş Stream		
	St. 1	**St. 2**	**St. 3**	**St. 4**	**St. 5**	**St. 6**	**St. 7**	**St. 8**	**St. 9**	**St. 10**	**Downstream**	**Upstream**	**S**
Borystenia naticina				+									N
Valvata kebapcii				+				+	+				N
P. antipodarum	+			+	+			+			+		NC
Pseudamnicola natolica	+				+								N
Theodoxus fluviatilis	+												N
Ancylus fluviatilis												+	N
Galba truncatula					+								N
Physella acuta	+			+	+	+		+	+	+		+	NC
Radix labiata	+				+			+	+	+			N
Gyraulus piscinarum	+			+	+			+	+			+	N
Dreissena polymorpha	+												N
Musculium lacustre												+	N
Euglesa casertana	+												NC
Pisidium subtruncatum				+						+			N
***Sphaerium* sp.**				+									N

Benthic samples were collected with a surber net from the different habitats in the stream including aquatic vegetation, stone-gravel, and sand. The samples were sieved with a series of strainer mesh sizes of 1, 0.5 and 0.25 mm, and then the snails were put into 75 % lab-grade ethanol in the field. Individuals counted one by one under stereo microscope to determine density in a unit area. A random sub-sampling was performed for shell measurements including shell height (SH), shell

width (SW) according to Glöer (2015). Shell measurements carried out by means of imaging system consisting of stereo microscope (Stemi 508, Zeiss) and a camera (Axiocam 105 color). At least 26 snails were included to measurements by sub-sampling. We also inspected to brood pouch contents of the sub-sampled snails in order to reveal seasonal reproductive efficiency. Randomly 15 snails per sub-sample unit were inspected for brood pouch regardless of their size.

Results and Discussion

Mollusca fauna and population structure of invasive species, *P. antipodarum*, inhabiting in two distinct areas were evaluated. Results showed that 12 and 5 taxa inhabiting in the Delice River and Kocabaş Streams respectively (Table 2, 3). The members of Mollusca fauna were assessed as nativeand non-native. There are 12 native and 3 non-native species were recorded in the two study areas (Table 1).

Potamopyrgus antipodarum originated from The New Zealand and *Physella acuta*, North American origin, are known as global invaders (Dillon et al. 2002; Semenchenko et al. 2008), so we can describe them as a non-native one in this study. In the stations of Delice River, a population with a higher number of individuals was detected (Figure 1, Table 2).

Table 2. Individual numbers per square meter of Mollusca found in the sampling stations (St.) of the Delice River.

Individual numbers	St. 1	St. 4	St. 5	St. 6	St. 8	St. 9	St. 10
Borystenia naticina	0	44	0	0	0	0	0
Valvata kebapcii	0	222	0	0	88	44	0
Potamopyrgus antipodarum	677144	44	133	0	89	0	0
Pseudamnicola natolica	44	0	88	0	0	0	0
Theodoxus fluviatilis	1909	0	0	0	0	0	0
Galba truncatula	0	0	1909	0	0	0	0
Physella acuta	16561	89	12318	14340	133	18958	44
Radix labiata	44	0	177	0	44	177	443
Gyraulus piscinarum	177	133	44	0	44	44	0
Dreissena polymorpha	44	0	0	0	0	0	0
Euglesa casertana	133	0	0	0	0	0	0
Pisidium subtruncatum	0	266	0	0	0	0	177
***Sphaerium* sp.**	0	44	0	0	0	0	0

Table 3. Individual numbers per square meter of Mollusca found in Kocabaş Stream

Individual numbers	Lw*	Up*
Potamopyrgus antipodarum	142	0
Ancylus fluviatilis	0	44
Physella acuta	0	22
Gyraulus piscinarum	0	22
Musculum lacustre	0	22

Lw: Lower part of the dam lake, Up: Upper part of the dam lake.

According to the community parameters in the Delice River, *P. antipodarum* predominated over the other mollusca taxa in the sampling site 1 (St. 1) (Figure 1). It has reached of the densest population in St. 1 with 56429/m^2 (Table 2). Among the sampling stations of the Delice River including 4th, 5th and 8th, *P. antipodarum* rarely established with a sparsely population (Table 2).

On the other hand, *P. antipodarum* was sampled from only one sampling site (lower dam Lake of Bakacak) with a few numbers of individuals (142/m^2) but predominated over associated species in Kocabaş Stream (Figure 4, Table 3).

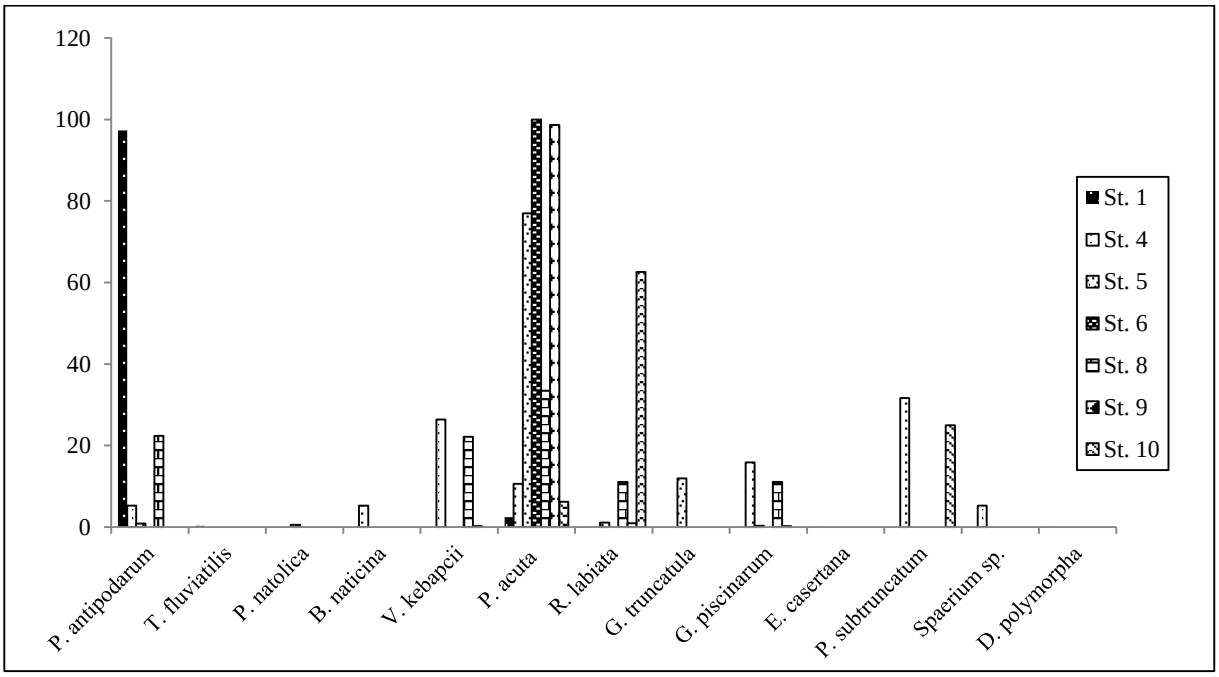

Figure 1. Dominance percentage of the Mollusca in the stations of the Delice River.

Considering the habitat structure and characteristics of the stations in which inhabiting of a *P. antipodarum* population in the study area, in the Delice River, the first station can be placed into a distinguished position among others as it is mainly fed by groundwater springs from the bottom (personal observation). *Theodoxus fluviatilis* and *Pseudamnicola natolica* are associated taxa with *P. antipodarum* supporting this claim because of their special habitat preference; springs (rheocrenes) and groundwater inhabitants (Yıldırım 1999; Falkner et al. 2001) that indicating the groundwater sources in the sampling region. According to the data, *P. antipodarum* might be considered as invasive for the region (1st station of the Delice River) due to a well-established population. Owing to the constant water quality regime throughout the year occurring in the spring-fed streams, they are suitable for growthof introduced species. The report of Hamada et al. (2013) also supports our findings that hot spring discharges are suitable habitats of *P. antipodarum* in Japan.

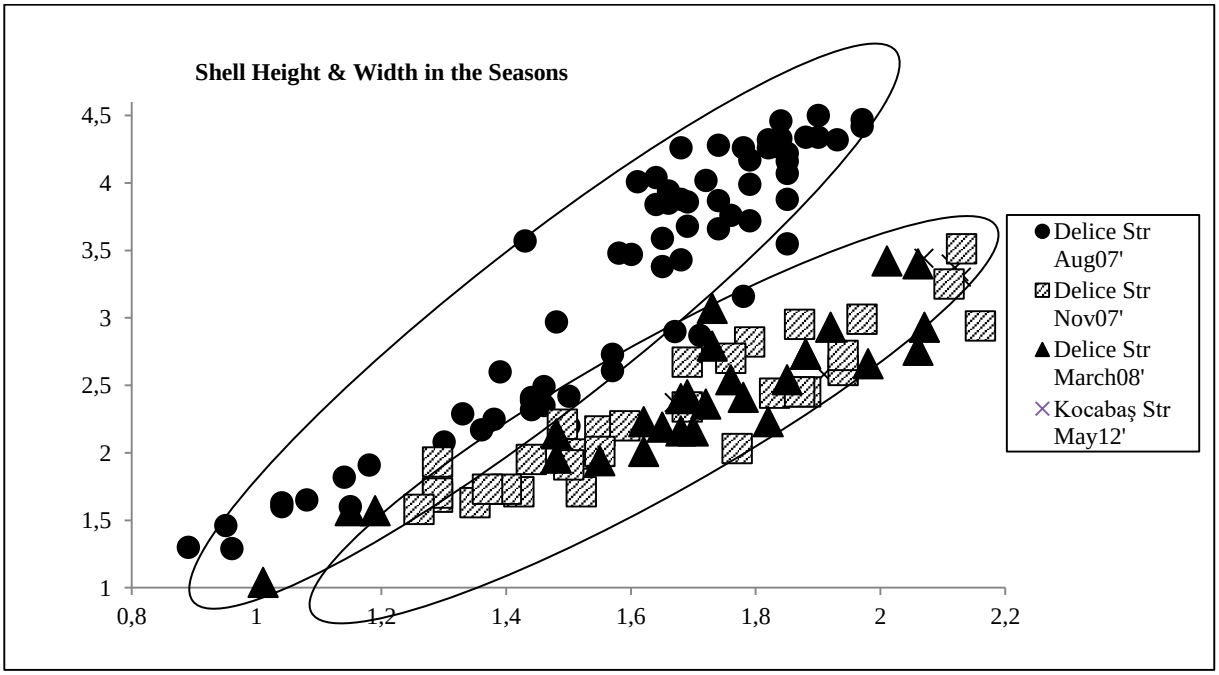

Figure 2. Seasonal shell height and shell width distributions of *P. antipodarum* in Delice River and Kocabaş Stream.

Shell height (SH) and width (SW) distributions of *P. antipodarum* revealed for streams in different seasons (Figure 2). As can be seen in the diagram, higher shells of *P. antipodarum* were observed in the season August 2007 in Delice River (Figure 2). Other seasons' SH and SW distributions of *P. antipodarum* belong to the streams were overlapped.

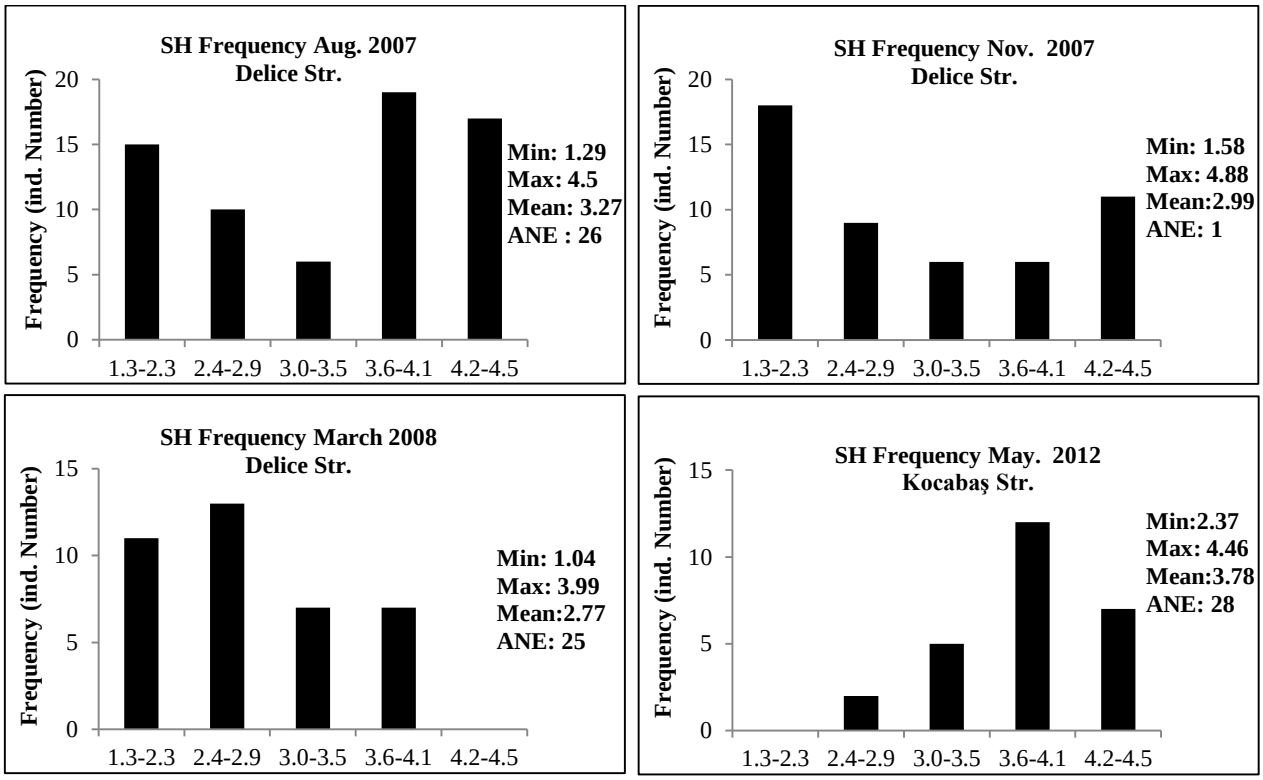

Figure 3. Seasonal shell height frequencies with maximum, minimum, mean values and the average number of embryo (ANE) of *P. antipodarum* in Delice River and Kocabaş Stream.

Snails were grouped into five SH ranges between minimum of 1.3 mm and maximum 4.5. Similar to SH distributions, higher frequency of appearance of longer shells were detected in the August 2007 of Delice River. On the contrary, the smaller SH ranges of shells assembled in the months March, May, and November, which are representing spring and autumn seasons. Minimum and maximum SH (mm) values, as expected, were in March and August 2007 respectively. Appearance frequency of the SH groups might be indicating that reproduction and individual growing occurred in seasons. Our data showed an annual life cycle for the seasons except winter. Accordingly, the first group range of the population, it can be considered as juveniles, were dominant group in November 2007 and March 2008 while the adults that can be placed into the last two SH groups were higher in number in August 2007. Although the sampling at the Kocabaş Stream coincided in early summer, growing population is visible by rising numbers of adult groups. As can be seen in charts, average number of embryo production was interrupted at Delice River only in November 2007 (Figure 3, ANE). The most productive season was early summer (in Kocabaş Stream) and summer (in Delice River). According to the brood pouch inspection, the minimum size of reproductive maturity was 3.47 mm in SH and 1.6 mm in SW bearing 21 embryos and neonates (Figure 3).

Dorgelo et al. (2014), revealed the dynamics of *P. antipodarum* populations inhabiting in two different lakes which have different trophic levels. The study showed that size distributions followed a regular annual pattern in the eutrophic lake. In this study, similar to our findings, smaller individuals that made a dense contribution to population size in one season, increased larger shells in the next season as reducing the number of smaller individuals. According to pouch analysis, embryo and neonates production was interrupted between November and February. Taking into account of the reproduction time and first reproduction maturity, a close similarity is observed with our study.

Before a species invade to an ecosystem, it has to overcome several challenges (Kolar and Lodge 2001; Sakai et al. 2001; Alonso and Castro-Díez 2008).

After the introduction of the species to a new environment, it must survive, grow and reproduce under the new environmental conditions (establishment). Furthermore, it must compete with the other organisms especially their ecologically similar taxa in order to reach a high population growth rate (invasion or spread). After that, the exotic species must alter the structure and functioning of the occupied ecosystem (impact) (Parker et al. 1999). In our study, as can be seen in Figure 1, *P. antipodarum* is successfully colonized at the 1st station of Delice River with an enormous number of individuals dominating the native mollusk community. Thus, there is a possible risk of impact on the native ecosystem in this site due to establishment success of the invader. Besides, *P. acuta* predominated over existing taxa at the other sites of Delice River. When we consider two non-native invaders, it is obvious that *P. antipodarum* is predominating *P. acuta* at the 1st station of Delice River. In Kocabaş Stream, there is no certain evidence about invasion processes of *P. antipodarum*. However, the species seems to reach an establishment success in the lower part of the Bakacak Dam in Kocabaş Stream (Figure 4).

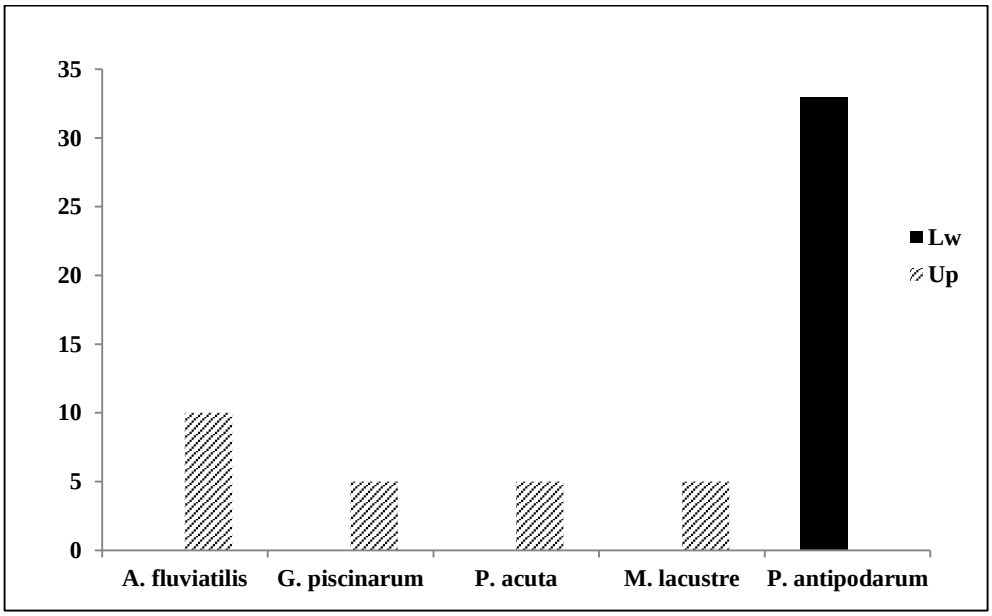

Figure 4. Dominance percentage of the Mollusca in the lower (Lw) and upper parts of the Dam Lake on the Kocabaş Stream.

In conclusion, further investigations and monitoring programs should be applied in order to clarify the influence of this non-native species on structure and functional ecology of the native benthic community.

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