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# Changes in the fauna of water mites (Acari: Parasitengona: Hydrachnidia) in small streams of the Bohemian-Moravian Highlands between the years 1964 and 2018

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**Abstract**. The contribution provides the information about the fauna of water mites in 14 localities of small watercourses in the Bohemian-Moravian Highlands that were sampled in 1964 and 2018. The exactly same methodology was applied to the samples and their processing in the same localities in both compared years. The main objective was to assess how the fauna of water mites have changed and if the occurrence of water mites can be used for the assessment of changes in water ecosystem conditions. The results showed that the abundance of water mites found in 2018 represented 47% of the numbers found in 1964. The number of the species found also decreased moderately from 33 to 28 in 2018. The changes in composition and frequency of occurrence of the water mite species found in both examined years are compared in detail. The results confirm that the fauna of water mites can be the important comprehensive indicator of biocoenosis changes in the ecosystems of small watercourses.

**Key words**. Water mites, small watercourses, changes of biocoenosis, Czech Republic.

## INTRODUCTION

Water mites belong to water organisms widely occurring in inland (fresh) waters and their use for the bioindication of the changes in water ecosystems is widely neglected (see e.g., Goldschmidt 2016). This might be due to the fact they do not have any critical importance for water ecosystems although they may significantly respond to biocoenosis changes, as indicate results of Biesiadka & Kowalik (1991), Gerecke & Schwoerbel (1991), Punčochář & Hrbáček (1991), and more recently e.g., Ciccolani et al. (2009), Miccoli et al. (2013), and Lewin et al. (2013). On the other hand, there is an extensive literature dealing with their taxonomy and occurrence. It is interesting in this respect that in the territory of Czech Republic, a number of prominent hydrachnologists have been dealing with water mites already from the 19th century. The most known contributions were published namely by Thon (1897, 1899), Komárek (1919, 1921), Halík (1925, 1929), and Láska (1951, 1966, 1971), who are also the authors of new water mite species, and in addition, they contributed to the unique knowledge about the anatomy and physiology of water mites. See Viets (1955), for more historical information.

This contribution is bounded to earlier publication Punčochář (1966), which contained the results of investigation of water mite fauna of several small streams, tributaries of the river Sázava, in the vicinity of the towns Světlá nad Sázavou and Ledeč nad Sázavou in the Bohemian-Moravian Highlands. The hilly catchments of these creeks on the right bank of the Sázava River basin lie on an area of approximately 600 km$^2$ of the agri-forest land.

The data on water mites found in 1964 led me to the intention to repeat the same investigation in 2018, as water ecosystems of small water courses (and inland water bodies in general) have been deteriotated by anthropogenic activities during past decades. Their biocoenoses have substantially changed from the original "natural state" as it is frequently discussed in the environmental literature and the recent data indicate the significant declining of the quantity of the insects. Of course, these changes of insect community may result from the limitation of the occurrence of the hosts of water mite larvae and this obviously may influence the composition of water mite fauna (quantity and quality). Thus, this situation was the background for the comparison of the water mite fauna composition found in the identical localities about half century ago (1964) with the situation in 2018.

## MATERIAL AND METHODS

In 2018, the samples of water mites were taken in the same localities and in mostly the same sampling points as in 1964, (see Appendix for detailed description) using the identical methodology as well as the following procedure of elaboration of samplings; i.e. there was used a sampling net with mesh diameter 60 µm, and the bottom, stone surfaces and riparian vegetation were washed off during the period of approximately 5 minutes. The water mites were picked up from the sample material and put to the Koenike's fluid still on the sampling site. The "traditional" method described by Viets (1936) was used for mounting microscopic preparations in glycerine-gelatine. The determination of collected water mites was based on the morphological features of the body, i.e. idiosoma and gnathosoma structures and their appendages were observed in the standard light microscope. The recent nomenclature published by Di Sabatino et al. (2010) and Gerecke (2009) was used for the identification of water mites and the synonyms described in these references (namely for the genus *Lebertia*) are included in the list of species for both years under comparison. This methodology enable direct comparison of the original determinations of found water mites of 1964 and the determinations of 2018.

The collected nymphs were not determining, they represented 3.8% and 2% of the total numbers of water mites found in 1964 and in 2018, respectively.

The results of the investigation in 1964 were published only in the Czech language with a brief English summary (Punčochář 1966) therefore the recent description of the individual localities contains both, their original state in 1964 as well as their current state in 2018. The changes are briefly summarized, which occurred at the individual sampling sites in the time interval of the compared years.

## RESULTS

In total, 33 species were found in 1964, whereas 28 species in 2018 (Table 1), and 16 species of water mites were found in both years. The highest numbers of occurring species belong to the genus *Lebertia* Neumann, 1880 (nine species), *Atractides* Koch, 1837 (seven species), and *Sperchon* Kramer, 1877 (six species), which is in agreement with their typical occurrence in the cold watercourses of mountains and sub-mountains watersheds.

The numbers of water mites found in 2018 with the same sampling effort were significantly lower in all investigated localities (Table 2) and they represented 47.3% of the number of 1964.

Table 3 contains the data from four localities where the highest numbers of water mites were recorded in 1964 as well as in 2018, representing about 57% and 65% of total numbers, respectively. Two of these localities (2 and 14) are the same for the two compared years, but numbers of water mites recorded here in 2018 reach only 52% and 73% of the numbers recorded in 1964.

When comparing the most frequently occurring species (Table 4), it is surprising that in 2018 the three species (*Lebertia glabra* Thor, 1897, *Lebertia pusilla* Koenike, 1911, and *Torrenticola amplexa* Koenike, 1908) did not belong to the most frequent ones in 1964. Similarly, the most frequently occurring species found in 1964 (*Atractides tener* Thor, 1899, *Atractides nodipalpis* Thor, 1899, and *Hygrobates longipalpis* Herman, 1804) were not found amongst the most frequent ones in 2018.

Table 5 summarizes the data on the highest species occurrence of water mites at six localities of which four localities are identical for both compared years.

Table 1. List of water mite species and their numbers found in the investigated localities. Names of the individual species have been adjusted according to Di Sabatino et al. (2010) and Gerecke (2009) for the findings from both years. For detail occurrence of the individual species see the supporting information; Nm = number of water mites, Nl = Nnumber of localities with their occurrence

| species of water mites | 1964 | | 2018 | |
|---|---|---|---|---|
| | Nm | Nl | Nm | Nl |
| *Atractides loricatus* Piersig, 1898 | 4 | 1 | – | – |
| *Atractides distans* (Viets, 1914) | – | – | 1 | 1 |
| *Atractides gibberipalpis* Piersig, 1898 | 7 | 3 | – | – |
| *Atractides nodipalpis* Thor, 1899 | 50 | 10 | 7 | 4 |
| *Atractides fonticolus* (Viets, 1920) | 4 | 2 | – | – |
| *Atractides spinipes* Koch, 1837 | – | – | 3 | 1 |
| *Atractides tener* Thor, 1899 | 5 | 5 | 1 | 1 |
| *Aturus scaber* Kramer, 1875 | 2 | 1 | – | – |
| *Aturus scaber rotundus* Romijn, 1921 | – | – | 1 | 1 |
| *Aturus spatulifer* Piersig, 1904 | – | – | 1 | 1 |
| *Arrenurus crassicaudatus* Kramer, 1875 | – | – | 2 | 1 |
| *Arrenurus* (*Megaluracarus*) *cylindratus* Piersig, 1896 | 2 | 1 | – | – |
| *Arrenurus* (*Megaluracarus*) *globator* | – | – | 3 | 1 |
| *Arrenurus* (*Megaluracarus*) *membranator* Thor, 1901 | 2 | 1 | – | – |
| *Feltria minuta* Koenike, 1892 | – | – | 1 | 1 |
| *Forelia variegator* (Koch, 1837) | 4 | 1 | – | – |
| *Hygrobates calliger* Piersig, 1896 | 134 | 11 | 7 | 3 |
| *Hygrobates fluviatilis* (Strom, 1768) | 2 | 1 | 1 | 1 |
| *Hygrobates longipalpis* (Herman, 1804) | 41 | 4 | 6 | 1 |
| *Hygrobates* (*Rivobates*) *norvegicus* (Thor, 1897) | 1 | 1 | 1 | 1 |
| *Lebertia* (s. str.) *dresdensis* Viets, 1928 [= sp. incerta, see Gerecke (2009)] | 4 | 3 | – | – |
| *Lebertia* (*Mixolebertia*) *dubia* Thor, 1899 | 14 | 2 | 1 | 1 |
| *Lebertia* (s. str.) *glabra* Thor, 1897 | 14 | 3 | 40 | 7 |
| *Lebertia* (*Pilolebertia*) *inaequalis* (Koch, 1837) | 1 | 1 | – | – |
| *Lebertia* (*Pilolebertia*) *porosa* Thor, 1900 | 1 | 1 | – | – |
| *Lebertia* (s. str.) *pusilla* Koenike, 1911 | 4 | 3 | 16 | 4 |
| *Lebertia* (s. str.) *rivulorum* Viets, 1933 | – | – | 1 | 1 |
| *Lebertia* (s. str.) *salebrosa* Koenike, 1908 | 1 | 1 | – | – |
| *Lebertia* (*Pilolebertia*) *saxonica* Thor, 1911 [= sp. incerta, see Gerecke (2009)] | 15 | 2 | – | – |
| *Limnesia koenikei* Piersig, 1894 | 3 | 1 | 17 | 1 |
| *Limnesia maculata* (Muller, 1776) | – | – | 1 | 1 |
| *Ljania bipapillata* Thor, 1898 | 3 | 2 | – | – |
| *Mideopsis orbicularis* (Muller, 1776) | 34 | 5 | 6 | 2 |
| *Piona conglobata* (Koch, 1836) | – | – | 2 | 1 |
| *Protzia eximia* (Protz, 1896) | – | – | 1 | 1 |
| *Protzia invalvaris* Piersig, 1898 | 2 | 1 | – | – |
| *Sperchon* (*Hispidosperchon*) *clupeifer* Piersig, 1896 | 14 | 7 | 13 | 6 |
| *Sperchon* (*Hispidosperchon*) *compactilis* Koenike, 1911 | 3 | 1 | 4 | 1 |
| *Sperchon* (s. str.) *glandulosus* Koenike, 1886 | 10 | 3 | 10 | 1 |
| *Sperchon* (*Hispidosperchon*) *hispidus* Koenike, 1895 | 9 | 4 | – | – |
| *Sperchon* (*Hispidosperchon*) *setiger* Thor, 1898 | 5 | 5 | 28 | 6 |
| *Sperchonopsis verrucosa* (Protz, 1896) | 8 | 4 | 7 | 2 |
| *Teutonia cometes* (Koch, 1837) | 14 | 2 | – | – |
| *Torrenticola (Torrenticola*) *amplexa* (Koenike, 1908) | 3 | 2 | 15 | 3 |
| *Torrenticola* (*Torrenticola*) *minutivalata* Lundblad, 1956 | – | – | 2 | 2 |
| total number of water mites (adults) | 421 | – | 199 | – |


Figs. 1–4. Examples of studied localities. All photos by P. Punčochář, 6 December 2020. 1 – locality No. 2, Žebrakovský potok brook. 2 – locality No. 9, Mrzkovický potok brook. 3 – locality No. 10, Pavlíkovský pramen spring. 4 – locality No. 13, Bohušický potok brook near Druhanov.

Table 2. Overview of the numbers of water mites and species found in the same localities in years 1964 and 2018; Nl = number of locality, Nm = number of water mites, Ns = number of species

| N1 | locality name | date 1964 | Nm | Ns | date 2018 | Nm | Ns |
|---|---|---|---|---|---|---|---|
| 1 | Žebrakovský potok, Světlá n. Sáz. | 19 IV | 11 | 4 | 12 V | 11 | 5 |
| 2 | Žebrakovský potok, Nový Dvůr | 26 IX | 57 | 10 | 26 V | 30 | 7 |
| 3 | Kunemilský potok, Josefodol | 25 IV | 19 | 5 | 23 VI | 1 | 1 |
| 4 | Kunemilský potok, Pod Zbožím | 26 IX | 12 | 8 | 23 VI | 1 | 1 |
| 5 | Přítok Kunemilského potoka | 26 IX | 11 | 7 | 23 VI | 4 | 2 |
| 6 | Vrbecký potok | 13 IX | 95 | 10 | 6 V | 4 | 3 |
| 7 | Zdrž na Vrbeckém potoce | 13 IX | 37 | 6 | 6 V | 35 | 7 |
| 8 | Olesenský potok | 13 IX | 31 | 10 | 6 V | 13 | 5 |
| 9 | Mrzkovický potok | 1 V | 38 | 6 | 23 VI | 13 | 6 |
| 10 | Pavlíkovský potok | 1 IX | 20 | 5 | 15 VII | 13 | 3 |
| 11 | Nezdínský (Vilémovický) potok | 1 IX | 9 | 5 | 15 VII | 9 | 3 |
| 12 | Pavlovský potok | 1 IX | 19 | 6 | 12 V | 5 | 2 |
| 13 | Bohušický potok u Druhanova | 4 X | 30 | 11 | 26 V | 25 | 6 |
| 14 | Bohušický potok, Světlá n. Sáz. | 4 X | 48 | 8 | 26 V | 35 | 7 |
| total number of adults | | | 421 | – | | 199 | – |

## DISCUSSION

The presented results show that total numbers of water mites in 14 localities in the compared years were in 2018 lower almost by half than in 1964. Similarly, also total numbers of the species found in 2018 were lower. The localities with the highest numbers of water mites and also with the highest species diversity are surprisingly mostly the same in the compared years despite the fact that the results from 2018 are lower. Four species of water mites of the seven most frequently occurring species were found in both years, indicating a certain stability of the occurrence of certain species.

Except for three localities (6, 7, 12), the other ones did not undergo any substantial/critical change of the stream bed as a result of a technical adjustment. Despite this, in all sampling sites, the conditions changed due to the bank vegetation and natural development of the streambed morphology. Namely, the depth of water in streambeds was lower as the consequence of sediments, the origin deeper pools practically disappeared, and the width of stream beds was also reduced by the growing riparian vegetation accompanying the sediment deposits. In all localities, the watercourse got in a significant shadow due to the development of the vegetation (trees, bushes), which is a consequence of the absence of regular management of stream banks along the watercourses almost in all sampled localities. The only tiny spring stream in the forest was the exception (locality 10, see Fig. 3), its character remained unchanged, the composition of water

Table 3. Localities with the highest numbers of water mites; n = number of water mites

| locality in 1964 | n | locality in 2018 | n |
|---|---|---|---|
| 6 – Vrbecký potok | 95 | 7 – Zdrž na Vrbeckém potoce | 35 |
| 2 – Žebrakovský potok, Nový Dvůr | 57 | 14 – Bohušický potok, Světlá n. Sáz. | 35 |
| 14 – Bohušický potok, Světlá n. Sáz. | 48 | 2 – Žebrakovský potok, Nový Dvůr | 30 |
| 9 – Mrzkovický potok | 38 | 13 – Bohušický potok u Druhanova | 25 |
| total numbers at these localities | 238 | total numbers at these localities | 125 |
| % of total number of all localities | 56.5 | % of total number of all localities | 65.4 |

Table 4. Species of water mites with the most frequent occurrence in the localities; n = number of localities

| species in 1964 | n | species in 2018 | n |
|---|---|---|---|
| *Hygrobates calliger* | 11 | *Lebertia glabra* | 7 |
| *Areactides nodipalpis* | 10 | *Sperchon clupeifer* | 6 |
| *Sperchon clupeifer* | 7 | *Sperchon setiger* | 6 |
| *Sperchon setiger* | 5 | *Atractides nodipalpis* | 4 |
| *Atractides tener* | 5 | *Lebertia pusilla* | 4 |
| *Mideopsis orbicularis* | 5 | *Hygrobates calliger* | 3 |
| *Hygrobates longipalpis* | 4 | *Torrenticola amplexa* | 3 |

mite species changed only slightly, and the *Sperchon glandulosus* Koenike, 1886 represented the most occurred species.

The majority of investigated localities have higher volume of sediments, depending on the management of farmland in the river basins. The former relatively small agriculture grounds, separated by the ridges, were unified into large fields during the period of socialist style of agriculture, in spite of sloppy areas (namely in the Bohemian-Moravian Highlands), causing an extensive water erosion. The soil erosion got into small watercourses and their streambeds were gradually filled with sediments. Due to the irregular occurrence of floods, the small watercourses became mostly very shallow. The climate changes caused repeated droughts and water scarcity since 2014, which accompanied increasing temperatures of air as well as of water, represent another important negative factors for the biota in small streams. The recent increase of the air annual average temperature by +1.1 °C was forecasted to happen after 2040 (Brázdil et al. 2012). The number of days with tropical temperature (above 30 °C) reached 47 days in 2018, which represented historical maximum. The existing scenarios of climate change (MACR 2019) expected these changes after 2070 only. The evaporation and evapotranspiration in landscape have been significantly increasing, contributing to the water scarcity and extreme low flow rates in all watercourses. However, the annual precipitation volumes remain the same even in the future, but their expected distribution in time might change dramatically and they might be accompanied by long periods of drought. The above phenomena will probably result into an increased occurrence of the reduced flow capacity of bed and by the disappearance of flow resting sections (“pools”) with a deeper water, which serve as refugia during dry periods. The situation of water flow in a long-term period in small watercourses in the Bohemian-Moravian Highlands is usually not as critical compared to the regions of a lower altitude. Nevertheless, the changed morphology of streambeds and the longer periods of low flow rates in small streams in forest-agriculture watersheds in the past six years (since 2014) have substantially differed from the long term (historical) situation, which was typical for the period at the 1960s. The pH values have not changed significantly, although and it is possible to observe their slight increase in several localities (see Appendix).

Table 5. Localities with the highest numbers of water mite species found; n = number of species

| locality in 1964 | n | locality in 2018 | n |
|---|---|---|---|
| 3 – Bohušický potok u Druhanova | 11 | 2 – Žebrakovský potok, Nový Dvůr | 7 |
| 2 – Žebrakovský potok, Nový Dvůr | 10 | 14 – Bohušický potok, Světlá nad Sázavou | 7 |
| 8 – Olesenský potok | 10 | 13 – Bohušický potok u Druhanova | 6 |
| 6 – Vrbecký potok | 10 | 9 – Mrzkovický potok | 6 |
| 14 – Bohušický potok, Světlá n. Sáz. | 8 | 1 – Žebrakovský potok, Světlá n. Sáz. | 5 |
| 4 – Kunemilský potok u Zboží | 8 | 8 – Olesenský potok | 5 |

When collecting water mites from the taken samples of bottom community, I registered an obvious decline in the occurrence of the larvae of midges (*Chironomidae*) and mayflies (*Ephemeroptera*) in 2018 compared with the situation in 1964. The numbers of the larvae of caddis flies (*Trichoptera*) and also the occurrence of "scuds" (*Gammarus* sp.) appeared comparable with my historical experience (by "memory"). Unfortunately, a quantitative expression is not available. The possible important decline in the occurrence of larvae of midges that are, especially in flowing waters, the important hosts of water mite larvae, could be a consequence of the application of plant protection preparations (pesticides) on the farmland in the river basins. The sloppy areas of the fields in the hilly terrain of the Bohemian-Moravian Highlands, cause a rapid surface flow of water from agriculture land, and when pesticides are applied shortly before rain, they lead to the contamination of water ecosystems in watersheds. This was repeatedly published not only in the Czech Republic (e.g. Liška et al. 2015), but also in the whole Europe (Doppler et al. 2014). The increasing pressure for the limiting of the pesticide application is applied in the actual EU legislation, which might improve the future situation of the water ecosystems and the water mites could be one of the important indicators of positive changes.

Despite the fact that the decline in the occurrence of water mites is clearly visible in the period between 1964 and 2018, to identify any obvious critical factor would be just a speculative estimate. Nevertheless, the obtained data confirmed that the water mite fauna can serve as the important "comprehensive indicator" of the ecosystem state in small watercourses. If the occurrence of water mites is low, it indicates an unfavourable situation of the water ecosystem of particular water bodies and it is necessary to identify causes and, consequently, to start with measures for the achievement of the "good ecological status", according to the objectives of the EU Directive 2000/60/EC. These findings are in a good agreement with the data published e.g. Goldschmit (2016) and Miccoli et al. (2013).

## SUMMARY

The results of the investigation of the water mite fauna in the samples from 14 localities in small streams in the Bohemian-Moravian Highlands in 1964 and 2018 show that the numbers of water mites in 2018 decreased to about half (47%) of the numbers found in 1964. Similarly, the species diversity in individual localities slightly decreased in the samples of 2018. These data confirm that the occurrence of water mites can serve as the indicator of conditions and changes of water ecosystems in small flowing waters. Despite the fact that it was not possible to identify the main reason for the changes found, a limited occurrence of the hosts of parasitic larvae of water mites may be one of the important factors. In addition, the hydromorphological changes of the streambeds, namely large increase of sediments and wide application of pesticides may have worsened conditions of the biocoenoses in most of the investigated localities. The data strengthen the importance of the water mite fauna as a comprehensive indicator of the ecosystem situation of small running waters.

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## APPENDIX

The list of the localities, their brief characteristics including the data on the changes taking place in the period between 1964–2018.

**1** (49.6613503N, 15.3887597E) – Žebrákovský potok brook below the town Světlá nad Sázavou, approximately 100 m above the flow in the river Sázava. Altitude 490 m a. s. l., the bed covered with stones and sand of coarser character, the width of the watercourse in the bed approximately 1 m. On 19 April 1964, water temperature 7.3 °C, pH=6.5. A vegetation development represents the main change; high trees in the riparian vegetation are the reason for a completely shaded watercourse. On 12 May 2018, water temperature 13 °C, pH=6.8.

**2** (49.7032850N, 15.3817639E) – Žebrákovský potok brook near the farm Nový Dvůr, under the spot height 550 m a. s. l. Sandy bottom, the stones covered with the moss Fontinalis. On 26 September 1964, water temperature 10.5 °C, pH<6.4. On 26 May 2018, water temperature 14.1 °C, pH=6.7. Since 1964, fundamental changes took place on the entire upper stretch of the brook; a dam reservoir was built in the place original sampling. For this reason, sampling site was located above the reservoir on the stream inflow at the new straightened bed framed by the wooden fortification. The streambed is covered with gravel, with no moss vegetation. These changes took place in the seventies, the wooden support still partially exists and causes accumulation of sandy sediments (see Fig. 2); the current accompanying riparian tree vegetation puts the watercourse in a complete shade.

**3** (49.6925025N, 15.4307217E) – Kunemilský potok brook in the municipality Josefodol, above the road, at the edge of the forest. Sandy bottom, with a detritus in the pools. The bed approximately 1.5m wide, approximately 0.4 m deep. Altitude 520 m a. s. l. On 25 April 1964, water temperature 6.7 °C, pH=6.9. On 23 June 2018, water temperature 13.5 °C, pH=6.7. The bed of watercourse adjusted, extended in many spots, showing the marks of a recent flooding situation, the bottom covered with a coarse sand and stones, practically without detritus sediments.

**4** (49.7057078N, 15.4562597E) – Kunemilský potok brook upstream of the locality 3, below the ponds at the municipality Zboží. Stony bottom, approximately 0.4 m deep, 1.3 m wide. Altitude 520 m a. s. l. On 29 June 1964, water temperature 12.4 °C, pH=7.2. On 23 June 2018, water temperature 11.2 °C, pH=6.5. The sampling point shifted approximately 400 m below the original sampling place, as the bed of watercourse was deepened and it lost torrentile character. The vegetation strongly covers shores of the adjusted streambed. A high number of macrozoobenthos – caddis flies, mayflies, "scuds", however, water mites were the only individuals.

**5** (49.7047181N, 15.4564025E) – a tributary entering the Kunemilský potok brook below the locality 4, a very small stream on a meadow covered with a riparian vegetation, width of the watercourse 0.3–0.5 m, the bottom consisting of sand and mud. Altitude approximately 500 m a. s. l. On 29 June 1964, water temperature 13.0 °C, pH=6.7. On 23 June 2018, water temperature 10.2 °C, pH=6.2. The sampling point practically identical with the situation of the former sampling in 1964, banks with the dense vegetation, which nearly cover the stream water level. The samples contain a high number of "scuds", larvae of mayflies and caddis flies, minimum numbers of the midge larvae. The very low occurrence of water mites.

**6** (49.7166822N, 15.2806369E) – Vrbecký potok brook above the confluence with the Olešenský potok brook, approximately 3.5 km above the town Ledeč nad Sázavou, at the altitude 360 m a. s. l. The stream flows through a forest, sandy bottom, the depth in the pools up to 0.6 m. On 13 September 1964, water temperature 10.0 °C, pH=6.8. On 6 May 2018, water temperature 11.5 °C, pH=6.8. The conditions of the locality changed very significantly, the bed of the Vrbecký potok brook was completely rebuilt and moved to another route, therefore the sampling place was located several hundred meters above the original locality. Sandy bottom – gravel bottom, dense riparian vegetation, water depth about 10–20 cm.

**7** (49.7161908N, 15.2816975E) – a small reservoir on the Vrbecký potok brook. A very shallow reservoir filled with mud, decaying fallen leaves on the bottom. Altitude 360 m a. s. l., water temperature 6.0 °C, pH=6.5. On **6** May 2018, water temperature 14.0 °C, pH=6.9. The reservoir was substantially extended and deepened; the accumulated water served for the operation of a small hydropower station. A dense zooplankton occurred in the water column, banks overgrown with the riparian vegetation.

**8** (49.7163353N, 15.2815831E) – Olešenský potok brook, above the confluence with the stream Vrbecký potok (i. e. locality 6). Stony bed with overgrown by filamentous algae. Altitude 365 m a. s. l. On 13 September 1964, water temperature 13.5 °C, pH=6.9. On 6 May 2018; temperature 11.5 °C, pH=6.7. The flow significantly weaker compared to the past years, the bed significantly narrower, up to 0.3 m deep. No periphyton algae occurring on the bottom surface.

**9** (49.6612122N, 15.3765319E) – Mrzkovický potok brook above the inlet to the Sázava river, on a meadow, approximately 3.5 km below the town Světlá nad Sázavou. The stream banks covered with dense riparian vegetation, stream bed with the muddy bottom. Altitude 375 m a. s. l. On 1 May 1964; water temperature 6.0 °C, pH=6.8. On 23 June 2018; water temperature 13.5 °C, pH=7.0. The bed adjusted, supported, dense riparian vegetation, which shadows the watercourse, bottom covered with a stony pavement. Sediments occurring only in the riparian zone together with the decomposed part of vegetation.

**10** (49.6732344N, 15.3344747E) – a spring of the Pavlíkovský potok brook, a very small, forest stream, close to a spring area (Fig. 3). The depth of watercourse up to 10–15 cm. Altitude 510 m a. s. l., on 26 August 1964, water temperature 7.5 °C, pH=6.6. On 15 July 2018, water temperature 13.4 °C, pH=6.1. The natural character of the bed did not change anyhow from the situation in 1964 (see Fig. 1). However, a reconstruction of the forest road is taking place, which might substantially influence the water regime in the future.

**11** (49.6987794N, 15.3146133E) – Nezdínský potok brook, flows through a forest, width of the bed 1 m, depth of the watercourse 0.5–0.7 m. Bottom covered with coarse sand. Altitude 450 m a. s. l., on 1 September 1964, water temperature 10.0 °C, pH=6.8. On 15 July 2018, water temperature 14.5 °C, pH=6.4. The bed became narrower, heavy deposits of mud and sand in the bed, the sampling point shifted approximately 300 m under the original locality of 1964. The forest is sparse due to bark beetle damage.

**12** (49.6956392N, 15.3355633E) – Pavlovský potok brook, a strong stream, the bed wide up to 2 m on a meadow, with a moderate turbulence, bottom covered with sand and fine mud. Altitude 465 m a. s. l. On 1 September 1964, water temperature 12.5 °C, pH=7.0. On 6 May 2018, water temperature 14.5 °C, pH=6.9. Compared to the past, the bed of stream was changed a lot in the length of approximately 2 km, and small ponds and barrages were built for the animal rescue station in Pavlov located above the original sampling point. Bottom covered with sand and mud, quite a lot of deposit, indicating previous flooding situations. Only several water mites were found; however, there was noted occurrence of many larvae of black flies, caddis flies, and mayflies.

**13** (49.6873397N, 15.4039747E) – Bohušický potok book near the small municipality of Druhanov, the sampling site located at the height about 515 m a. s. l., the stream course in forested area, 0.4 m deep, the bed 0.6 m wide. On 4 October 1964, water temperature 8.5 °C, pH=6.7. On 26 May 2018, water temperature 15.0 °C, pH=6.5. As compared to the past, stream bed with heavy deposits of sandy-mud sediments, very shallow flow, practically without stones. The original young (small) forest grew into tall trees, which completely shadow the stream cource.

**14** (49.6778758N, 15.4050422E) – Bohušický potok brook above the urban area of the town Světlá nad Sázavou. The stream bed up to 1.5 m wide, up to 0.4 m deep. Bottom covered with detritus, a muddy sediment in the pools. Altitude 400 m a. s. l. On 4 October 1964, water temperature 9.0 °C, pH=7.2. On 26 May 2018, water temperature 15.2 °C, pH=6.4. Compared to the past situation, the streambed narrower, up to 1 m wide, up to 0.3 m deep, bottom covered with sand and mud, the dense of riparian vegetation, and trees and bushes shadow the stream course. The water slightly cloudy, probably due to the soil erosion in the upper part of the watershed.

The general comments to the changes of localities between 1964 and 2018 years are following: the most frequent and most serious changes in the individual sampling localities: a decreased depth of water in the bed, a bigger amount of sediments, changes of the character of sediments (fine mud caused by higher soil erosion). The riparian and bank vegetation significantly reduced the width of the streambeds practically at all sampling points (see Figs. 1, 2, 4 – pictures were taken in the autumn, when the stream bed can be visible).