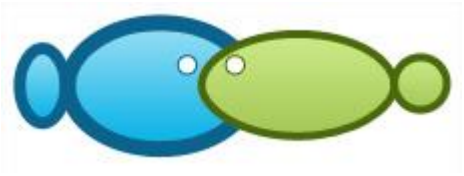

The first record of insect *Podura aquatica* L. (Collembola, Isotomidae) in southern Iraq with some environmental parameters effect on its density

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Abstract. Generally, Collembola does not attract the attention of researchers and the studies on it are limited in the Middle East and especially in Iraq. This is the first record of the insect *Podura aquatica* in the region of south Iraq, it appeared during winter and spring seasons, and it completely disappeared during summer. The study showed the relation between the insect and some environmental parameters such as temperature, PH, electric conductivity (EC), and total organic carbon (TOC). There was significant negative correlation between the insect density and temperature, pH, and TOC. While there was a weak positive correlation between density and EC. The area of study suffered from high levels of organic matter due to the dumping of sewage water of Basrah governorate into Shatt Al-Basrah River, and it increased in summer due to the death of attached algae and tidal plants.
Key Words: Shatt Al-Basrah, springtail, wastewater.

Introduction. Collembola - popularly known as springtail are small primitive and wingless insects. English entomologist Sir John Lubbock gave the name of Collembola in 1870 for this group of insects (Lubbock 1873). These insects are small with a range of sizes from 0.25mm to 6 mm in length and vary in color (Greenslade & Ireson 1986). There are 7,500 described species around the world (Hopkin 1997).

Their antennas have 4 to 6 segments. They are minor pests in agriculture, but their importance as a biological factor in the process of soil formation is important. Many Collembolan species are now a vital indicator of soil pollution as well soil fertility. Collembola has a very wide distribution, occurring all over the world, and in many habitats, even in the south polar region (up to 77° latitude south in Antarctica) (Sinclair & Sjursen 2001; McGaughran et al 2011). Few species live permanently on glaciers or frozen areas. The greatest variety of insects is found in regions with high organic matter content in soil. Some species live freely on the surface of the water (i.e., *Podura aquatica*). They are less abundant in dry habitats. Approximately, there are 7,500 described species in the world (Hazra & Mandal 2007).

The common name for insects of this group is springtail, given due to the existence of an organ attached to the ventral surface of the fourth abdominal segment of the abdomen. It is present in most species, and sometimes it is absent or weakly growing. The structure consists of a pair of appendages fused in the base to form the manubrium. From this basal part there is a pair of separate structures known as dentes, attached with a small hook-like structure called mucrones (Richards & Davies 1977; Gillott 2005).

The family Poduridae includes a single, famous species, *Podura aquatica* L., 1758. It is, possibly, the most usual and readily recognized springtail. Ordinary on the surface of water bodies in the Northern Hemisphere, large numbers of them often swarm during summer in the shaded corners of slow-stream water and ponds. It is no more than 1.3 mm long and is ordinarily blue-black with reddish appendages; sometimes it is totally red brown. Its antennae are usually shorter than the head and have eight eyes on each flank. All abdominal segments are distinctly separate. The furcula is roughly long, extended to the collophore when at rest. The cuticle is coarsely granulated (Bland & Jaques 2010; Cipola et al 2018). Alyousuf and Nikpay (2020) presented a survey on the types of insects that are economically relevant in Basra Governorate, southern Iraq.

Material and Method. The samples were collected during December 2020 to July 2021 from an area located in the west of Basrah province in Iraq on Shatt Al-Basrah River (N30^{O}24’7”, E47^{O}46’49”) (Figure 1), which it is an industrial water channel branching system from the Garma River, northwest of Basrah, heading east of Al-Zubayr until it is drained in the Khor Al-Zubayr lagoon, then to the Arabian Gulf.

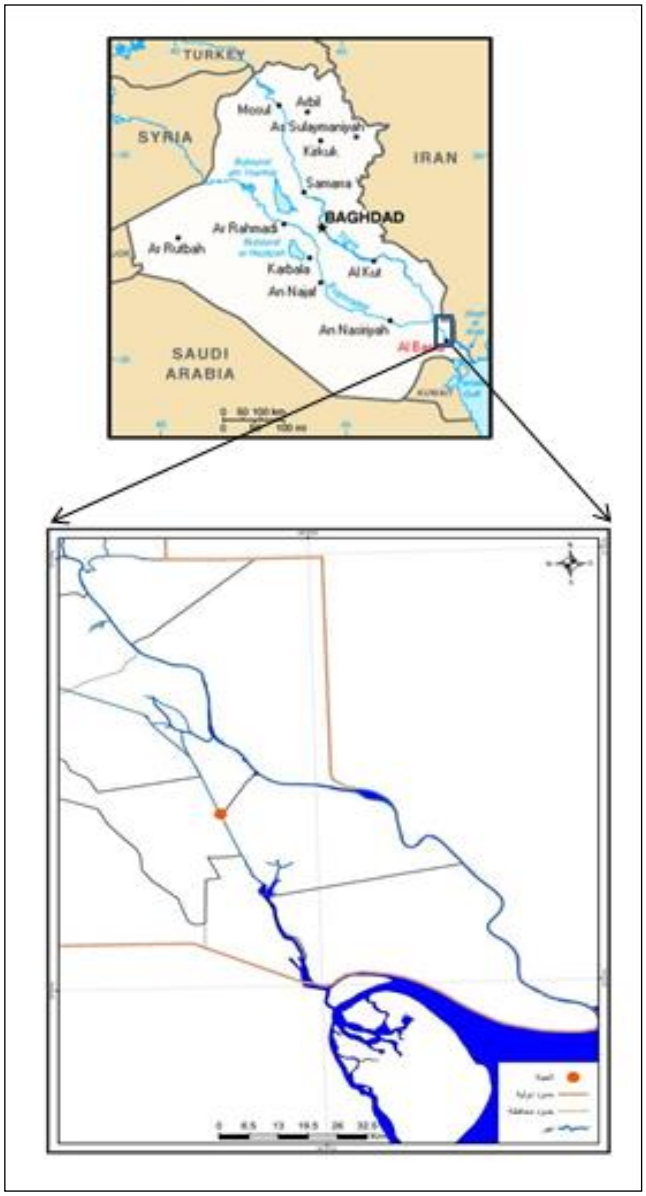

Figure 1. The position of samples collection in Basrah province (map generated using Arc GIS v. 10.6).

The area is characterized by being a tidal zone, in which the water will rise to cover approximately 20 meters during high tides. It is also characterized by a dense and renewed growth throughout the year of the tidal plant *Hammada salicornia* and the growth of blue-green algae and diatoms covering the soil surface (Figure 2). Where insects resort to plant branches and holes in the soil to hide and take shelter from high temperature. The area is also rich with many gatherings of mud skippers which belong to two species *Periophthalmus waltoni* and *Boleophthalmus dussumieri*, as well as the wide spread of holes made by digging crabs (*Nasima dotilliformis*, *Leptochryseus kuwaitensis* and *Ilyoplax stevensi*).

Figure 2. The tidal plant *Hammada salicornia* and algae in sampling place.

Shatt Al-Basra River is now considered a stream for heavy water for Basrah province, the river course being characterized by high levels of pollution on its banks, due to the dumping of construction waste, slaughter houses waste and sewage water (Hassan et al 2019) (Figure 3).

Triplicate samples were collected by using the quadrate sampling method (5x5 cm), with soil core samples collected from a depth of 5 cm, which were then transported in containers to the Invertebrate Laboratory in the Department of Biology of the College for Education for Pure Sciences at the University of Basrah, and fauna was isolated in the next 24 hours. The temperature, pH, electric conductivity (EC), total organic carbon (TOC) were recorded simultaneous and soil texture was estimated.

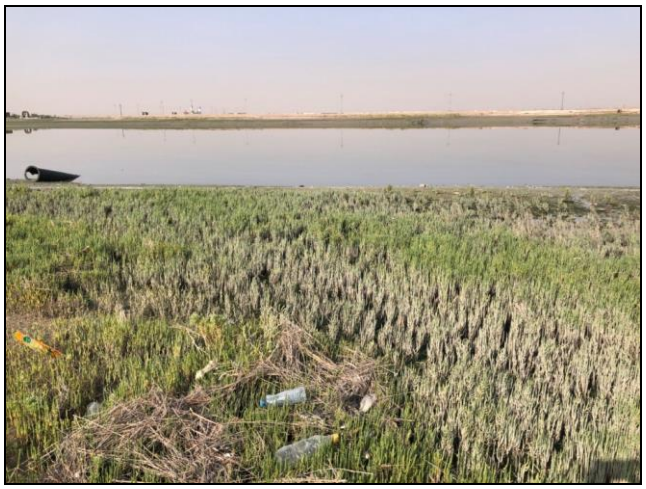

Figure 3. Wastewater and waste thrown in Shatt Al-Basrah River.

Statistical analysis. The results were analyzed by using the program Canonical Correspondence Analysis (CCA) to determine the extent of the influence of environmental factors on the density of the insects and the extent of the interaction between the factors and its density. The program Paleontological Statistics (PAST) was used to determine the strength and type of the relation between density of insects and every environmental parameter.

Results. The samples had been collected during winter (December, January and February), spring (March, April and May) and the beginning of summer (June) in Iraq.

Table 1 refers to the environmental parameters analyzed during this study. The temperature ranged between 8^{O}C which is the lowest temperature recorded in January 2021 and 35^{O}C which is the highest temperature recorded in May and June. pH ranged between 6.2 in December to 7.5 in May, meaning the soil tends to acidic. Electrical conductivity (EC) ranged between 12.34 ms/cm in May to 12.34 ms/cm in April. The total organic carbon (TOC) was calculated per 1 gram of soil, and it ranged between 120mg/g recorded in March to 270mg/g recorded in May.

Table 1

The environmental parameters recorded during study period

Month	*^{O}C*	*pH*	*EC mS/L*	*TOC mg/g*
December2020	12	6.2	14.63	225
January2021	8	6.8	16.18	170
February	21	6.5	17.24	125
March	24	7.2	17.69	120
April	33	6.9	18.20	155
May	35	7.5	12.34	270
June	35	7.2	15.74	265

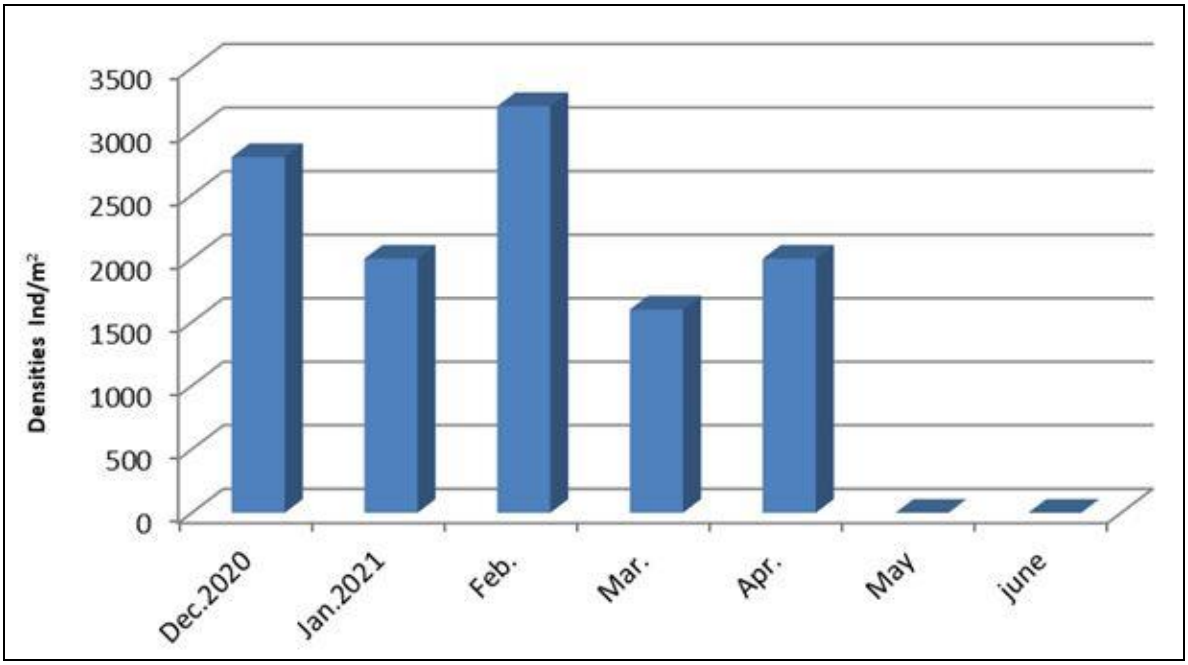

Figure 4. The density of insect *Podura aquatica* per square meter during study period.

Figure 4 shows the densities of *Podura aquatica* during the study period, which recorded the highest density in February that reached 3200 ind/m^2 then the insect numbers began to decrease until they disappeared in May and June.

Figure 5. Dry soil during summer season in location of study.

The samples were collected from an intertidal area that receives water twice a day, but starting from March, the high temperature leads to the evaporation of moisture when the tide recedes rapidly. Figure 5 shows the dry soil during low tide, which led to the disappearance of the adherent algae that had been abounded in the area and did not tolerate drought conditions.

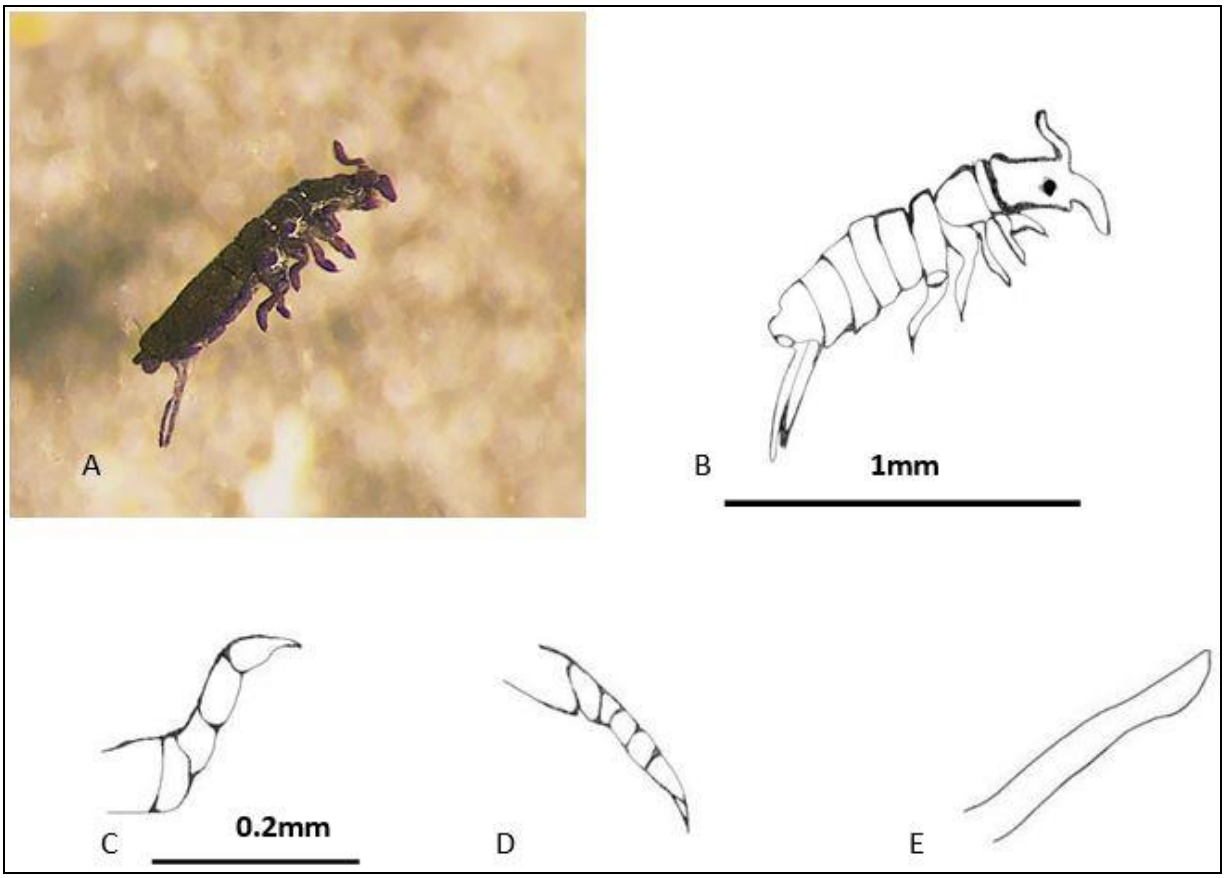

Figure 6. *Podura aquatica*: (A) under the microscope at a magnification of 400x; (B,C,D and E) the whole body and their appendages draw with a camera lucida; (C) the second leg; (D) the third leg; (E) furcula (the spring organ).

The length of *Podura aquatica* was recorded at about 1.3 mm with the furcula, the first and the second pair of legs consists of five segments and the third pair consists of six segments. However, the legs seemed to be of equal length.

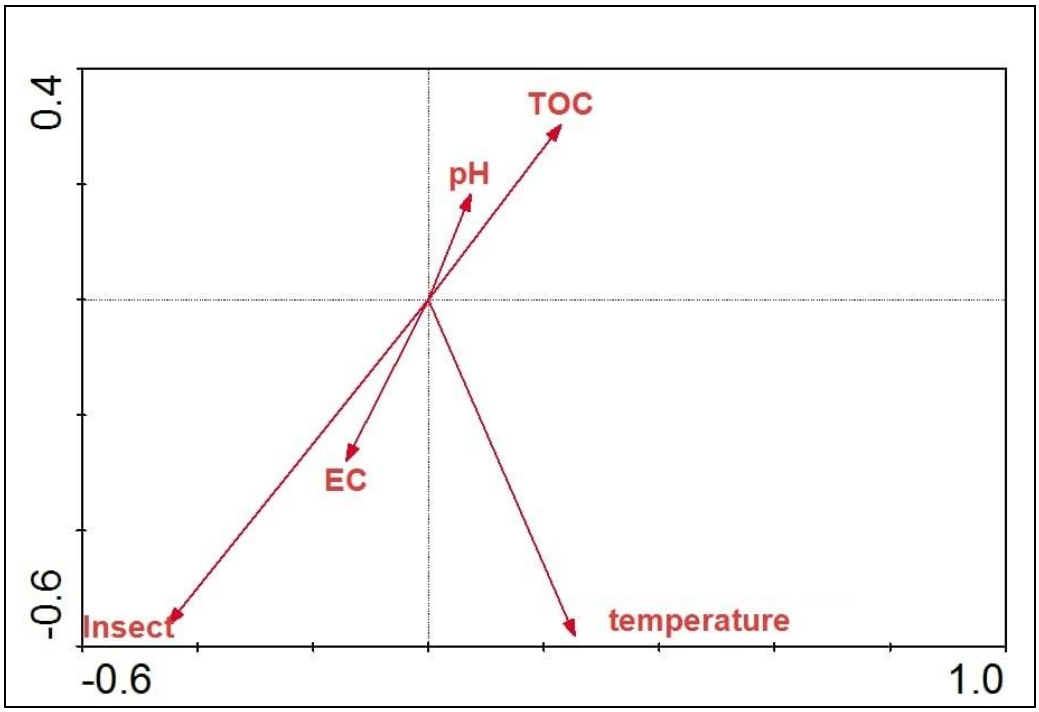

Figure 7. CCA software revealed the relation between insect density and the studied parameters (temperature, pH, EC and TOC).

Discussion. Collembola got a little attention around the world, but some of them are listed as damaging pastures as Greenslade (1995) study on agricultural pest species in Australia shows. The region samples were characterized by high level of organic matter, and that's because the sewage water of Basrah province is poured into Shatt Al–Basrah River and is collected in a tidal zone, where it is exposed to rising water twice a day, and its percentage increased more during the summer due to the death of attached algae and lots of tidal plants. Cassgne et al (2003) found a high correlation between Collembola and organic matter, and the results of this study showed a positive relationship between them. The result of study agreed with Ponge (2000) that the relation between insect density and pH was negatively correlated. The results of study showed there was a negative relation between the density of *Podura aquatica* and the temperature (r=-0.68) and it began to decrease during spring and is completely absent during summer, which agreed with Childs (1915) study on life history of *Podura*, where he found that the insects number began to increase when the weather was colder, and also agreed with the study of Hertzberg and Leinaas (1998) on two species of Collembola, in which they found that insects number decreased in high temperature. The results also found a significant negative relation between the insect density and PH (r=-0.88), obviously in the decrease of insect numbers when the pH increased and a significant negative relation with total organic carbon (TOC) (r=-0.69).

With the rise in temperature in the spring and summer months, the evaporation rates of water rise in the tidal area, which leads to the death of attached algae and a large percentage of tidal plants, which in turn was the reason for the high rates of organic matter and pH in the sediments, as Luo et al (2014) study found that Collembolas are more sensitive to pH and organic soil, which explained the absence of the insect during summer. Also, the study of Ke et al (2004) found that Collembola prefer a pH of 8 and they may be tolerant to high pH but are sensitive to acidic conditions.

Moreover, the statistical analysis found that there was a weak positive relation between insect densities and EC (r=0.49).

Conclusions. The insect *Podura aquatica* was first recorded during this study in Iraq, and it was found that it is sensitive to environmental conditions, especially TOC. The region needs more studies on the Collembola insects in general and *Podura aquatica* especially.

Conflict of interest. The authors declare that there is no conflict of interest.

References

Alyousuf A., Nikpay A., 2020 Economic importance insects of the plantations in Basrah Province, Iraq. Ann Agric Crop Sci, 5(2):1061.

Bland R. G., Jaques H. E., 2010 How to know the insects. Waveland Press.

Cassagne N., Gers C., Gauquelin T., 2003 Relationships between Collembola, soil chemistry and humus types in forest stands (France). Biology and Fertility of Soils, 37(6):355-361.

Childs G. H., 1915 Some observations on the life history of the water springtail (*Podura aquatica*-1758).

Cipola N. G., da Silva D. D., Bellini B. C., 2018 Class Collembola. In Thorp and Covich's Freshwater Invertebrates (pp. 11-55). Academic Press.

Gillott C., 2005 Apterygote hexapods. Entomology, 113-125.

Greenslade P., Ireson J. E., 1986 Collembola of the southern Australian culture steppe and urban environments: a review of their pest status and key to identification. Australian Journal of Entomology, 25(4):273-291.

Greenslade P., 1995 A review of the biology, taxonomy and pest status of *Entomobrya unostrigata* (Collembola: Entomobryidae)—an introduced species of agricultural land in Australia. Polskie Pismo Entomologiczne, 64(1-4).

Hassan A. A., Dawood A. S., AL-Mansori N. J., 2019 Assessment of water quality of Shatt Al-Basrah canal using water pollution index. Int J Eng Technol, 8(1.5):325-331.

Hazra A. K., Mandal G. P., 2007 Pictorial handbook on Indian Collembola (Part-l):1-34.

Hertzberg K., Leinaas H. P., 1998 Drought stress as a mortality factor in two pairs of sympatric species of Collembola at Spitsbergen, Svalbard. Polar Biology, 19(5):302-306.

Hopkin S. P., 1997 Biology of the springtails: (Insecta: Collembola). OUP Oxford.

Ke X., Yang Y., Yin W. Y., Xue L., 2004 Effects of low pH environment on the collembolan *Onychiurus yaodai*. Pedobiologia, 48(5-6):545-550.

Lubbock J., 1873 On the origin and metamorphoses of insects. Nature 8:107–109.

Luo W., Verweij R. A., van Gestel C. A., 2014 Assessment of the bioavailability and toxicity of lead polluted soils using a combination of chemical approaches and bioassays with the collembolan *Folsomia candida*. Journal of hazardous materials, 280:524-530.

McGaughran A., Stevens M. I., Hogg I. D., Carapelli A., 2011 Extreme glacial legacies: a synthesis of the Antarctic springtail phylogeographic record. Insects, 2(2):62-82.

Richards O. W., Davies R. G., 1977 Imms' general textbook of entomology (Vol. 2). Springer Science & Business Media.

Ponge J. F., 2000 Vertical distribution of Collembola (Hexapoda) and their food resources in organic horizons of beech forests. Biology and fertility of soils, 32(6):508-522.

Sinclair B. J., Sjursen H., 2001 Cold tolerance of the Antarctic springtail *Gomphiocephalus hodgsoni* (Collembola, Hypogastruridae). Antarctic Science, 13(3):271-279.

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