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The Impact of Sowbug (*Hemilepistus shirazi* Schuttz) on Infiltration Ratein a Arid Region, Iran

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Abstract: Desertification control through Floodwater Spreading (FWS) mainly for the Artificial Recharge of Groundwater (ARG) is comprehensive study that is being implemented since, Jan. 1983 in the Gareh Bygone Plain (GBP) in Southern of Iran. Eight ARG systems with a total area of 1365 ha were constructed during the 1983-1987 period on the debris cone and alluvial fan formed by the Bisheh Zard river, an ephemeral stream that supplies floodwater to the GBP from none to 8 times a year. The inevitable Malthusian dilemma however may be delayed through the application of the artificial recharge of groundwater methods using the turbid floodwaters that abound in most deserts. While soil building is a highly desirable outcome of the ARG activities, formation of a hard crust that substantially decreases infiltrability of sedimentation basins and recharge ponds is a negative attribute of using turbid waters for the ARG. This problem was delicately solved by nature when a population of sowbug (*Hemilepistus shirazi* Schuttz) invaded the ARG systems in the Gareh Bygone plain in Southern Iran. The burrows made by this crustacean have a circular opening 7 mm in diameter and reach a depth of 80 cm. The infiltration rate of the areas punctured by the burrows as determined by the double ring method had increased 4.2 fold in some plots, in comparison with control. Statistical investigation shows that there is a significant difference between sowbug and control. This difference was significant at the 1% level. Cautious introduction of plants attractive to this useful organism is an environmentally sound and a financially viable method of lengthening the economic life of the ARG system.

Key words: Economic life, lengthening, organism, groundwater, farmland, production

INTRODUCTION

Malthusian dilemma shall be realized in about 100 years if the current trends of land degradation, conversion of prime farmlands to non-agricultural uses, impending water crisis and population growth continue unchanged. Desertification control through floodwater spreading particularly for the Artificial Recharge of Groundwater (ARG) on a very large scale however, may delay this ultimate disaster. In the meantime, scientific breakthroughs in birth control and food production may hopefully reverse this predicament.

Implementation of the ARG methods in the deserts underlain with potential aquifers not only replenishes the underground reservoirs but also rehabilitates the drastically disturbed lands through sedimentation of nutritious suspended load that abounds in floodwater onto them (Kowsar, 1998, 2005). This, at least in the land of Iran is mainly due to the extreme erosivity of the Miocene marls, siltstones and sandstones that cover most of our flood-producing basins. These particles that are the nemeses of hydraulic engineers, particularly dam builders are a boon to conservationists as they utilize them to rehabilitate the eroded land and to transform the coarse-textured, infertile soils into productive fields.

Soil building in sedimentation basins, the integral part of the ARG systems has converted 1365 ha of a moving sand menace into a fertile land in the Gareh Bygone Plain (GBP) in southern Iran (Kowsar, 1991, 2005). One of the main theoretical constraints of this successful project was the inevitable impermeability of the ARG systems due to deposition of the suspended load onto the sedimentation basins and recharge ponds and the downward migration of fine clay particles, specifically those of chlorite, palygorskite and smectite through the soil profile (Mohammadnia and Kowsar, 2003).

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As surface tillage practices that increase soil macro-prosity and infiltration rate is harmful to the tree roots planted in the basins and their effects are usually short-lived, terminating with the deposition of fine-grated suspended load during the next flooding we had to resort to biological means. The researchers knew that decomposition of *Eucalyptus camaldulensis* Dehnh. roots, planted in the basins, would form channels that facilitate preferential flow towards the watertable. However, surface sealing by a very hard crust with an ever increasing thickness would hinder the smooth flow of water toward the rooting zone. Therefore, drilling of numerous biopores in the crusts was the method of choice.

It is well-known that various macro fauna inhabit the soil and modify some of its properties (Pankhurst and Lynch, 1994; Nardi, 2007). Tunnelling, mounding and pedoturbation are some of the most observable activities that have attracted the attention of soil scientists. Ants, beetles, cicadas, termites, worms and crayfish are a few of the fauna whose activities which somehow resemble those of the sowbug have been studied. Baxter and Hole (1967) investigated the ant (*Formica cinerea montana* Emery) activities in grant county, Wisconsin. Salem and Hole (1968) studied the ant (*Formica exsectoides* Forel) mounds in lafayette county, Wiscosin. Wiken *et al.* (1976) reported on the ant (*Formica fusca* L.) activities in northeast of Mt. Talow in British Columbia and Levan and Stone (1983) researched soil modification by *Formica fusca* L. in centeral New York. These investigators found ant tunnels at depths ranging from 120-150 cm. Soil mixing by scarab beetles (*Peltotrupes youngi*) was studied by Kalisz and Stone (1984) in the Ocala National forest in Florida. Although, they measured burrows as deep as 3.6 m, these authors speculated that *P. youngi* may burrow down to 5 m.

Mermut *et al.* (1984) and Jones (1989) studied termite mounds in Kenya and Tanzania, respectively. The latter investigator discovered indicator plants for the geological formations where specific species of termites were active. Luken and Kalisz reported that three cicada species (*Magicicada cassini*, *M. sependesim* and *M. septendecula*) that live underground for a period of either 13 or 17 years, burrow to a depth of 36 cm. As their density may reach as high as 1,700,000 ha^{-1} they should have quite an impact on soil infiltrability. Stone (1993) found that a crayfish (*Procambarus rogersi* Hobbs.) excavates galleries 4-10 cm in diameter and longer than 1.5 m, chiefly in the upper 30 cm of soil but with vertical shafts deeper than 1 m. Although, all of the burrows made by the above mentioned animals could function as flow path for water and solutes, this point was not an objective of these investigations.

The appearance of many circular biopores next to quailbush (*Atriplex lentiformis* (Torr.) Wats.) in the spring of 1992, 10 years into the project was a glad tiding for us. Close examination revealed mild infestation of these bushes by a sowbug species (*Hemilepistus shirazi* Schuttz). Preliminary sounding of the burrows indicated the presence of a vertical shaft, 30-40 cm deep in each one. The rapid infiltration of floodwater into the hard crust formed by the dried fine sediment and perforated by the sowbug encouraged us to investigate different aspects of this very useful gift of nature. This is the first in a series of reports in which we present a brief description of the arthropod the architecture of its burrows and infiltrability enhancement of the perforated crust. Some physico-chemical properties of the extracted materials deposited on one side of each burrow. The composition of the lining of its burros, the micro-organisms that inhabit its digestive and anatomy will be reported later.

Description of the sowbug: This organism is a crustacean, 15 mm long and 5 mm wide. It is blackish gray and has 7 pairs of legs (Fig. 1). Unlike pillbug it is not capable of rolling up into a ball. This organism has been classified as follows (Robert, 1980):

Gategory: Metazoa
Phylum: Arthropoda
Subphylum: Mandibulate
Class: Crustacea
Order: Isopoda
Suborder: Oniscoidae
Genus: *Hemilepistus*

Sowbugs live in damp places, forage on vegetation and digest the soil organic matter. Their burrows, 7 mm in

Fig. 1: A dorsal view of a female *Hemilepistus shirazi* Schuttz

Fig. 2: The parallelepiped-shaped burrowed material

diameter and up to 80 cm deep, serve to aerate and drain the soil profile. The same genus or one of its close relatives burrows down to 100 cm in Gonabad, NE Iran (Rahimi, 1993). The northward extension of *Hemilepistus* sp. reaches Central Asia where they may be found up to 100 m^{-2} burrowing down to 80 cm and excavating up to 1.5 ton ha^{-1} of soil in their active period of about 3 months.

The excavated soil has more organic matter and a better structure thus is more resistant to erosion than the original soil form which it was extracted (Rastin, 1978). This viviparous organism lives for about 1 year. The white brood pouch under the abdomen of the female swells in March. The eggs form larvae in the pouch and 60-70 sowbugs, very similar to their parents are released from the pouch in May.

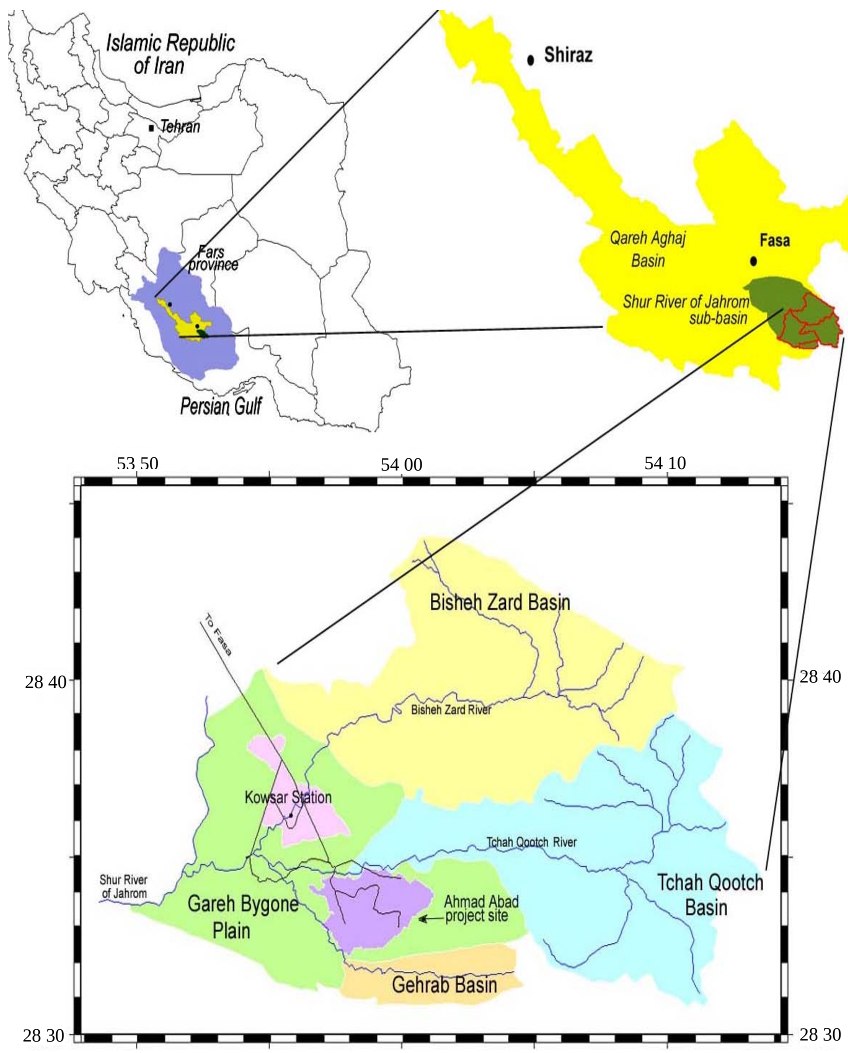

Fig. 3: The map of site study

They are very active in the spring and fall. They come out of their burrows in the cool air of early morning and late afternoon. It seems that digging deep into the soil is to reach a humid surrounding. There are semi-spherical spaces at the end of their burrows, 5-10 cm in diameter. They form semi-cylinderical, rods of soil, 2 mm long and 1 mm in diameter with their mandibules and place them to one side of the opening of their burrows (Fig. 2). These rods are seemingly more resistant to slaking than the freshly laid sediment from which they are formed. As some remains of the sowbug are found in scorpion burrows, it is believed that that *Hemilepistus shirazi* Schutz is eaten by this arachnid.

MATERIALS AND METHODS

This study was performed at the Kowsar Floodwater Spreading and Aquifer Management Research, Training and Extension Station in the Gareh Bygone Plain, 200 km to the SE of Shiraz, Iran on the debris cone of the Bisheh Zard river (Fig. 3). The major soil of the site is a loamy sand (coarse-loamy over loamy skeletal, carbonatic, (hyper) thermic, typic haplocalcids). Eight ARG systems, covering a total area of 1365 ha were installed during the 1983-1988 period. More details may be found elsewhere (Kowsar, 1991, 1998). Configuration of the burrows was studied by making their paraffin casts. Measured volumes of molten paraffin wax were poured into the burrows through a long-stemmed glass funnel. The casts were removed from the soil profile by digging diligently around them making sure that the broken pieces were placed in proper order then photographing them (Fig. 4). It should be mentioned that the lateral penetration of the molten wax into the wall of the burrows made the cast

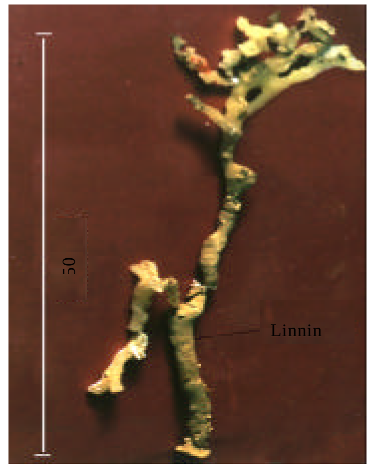

Fig. 4: Paraffin wax cast of a sowbug burrow. The opening is on the top

Fig. 5: Location of the 2nd sedimentation basin of BZ1 from the view of Google Earth showing the SPOT image of the year 2007

diameter 4-5 times their true measurement of 7 mm. The walls of sowbug burrows are quite durable. Apparently, the sowbug wet and cement their burrows with salvia (article under preparation). An extremely thin coating of a greyish material lines the burrows in a very fine sand that collapse otherwise.

Infiltrability of 11 paired plots (with and without the sowbug burrows) were determined utilizing the double ring method (Anonymous, 1990), in the one of the floodwater spreading systems which was designed and constructed in 1983 (Fig. 5). We measured infiltration rate every plot in each pair of plot during the same day.

RESULTS AND DISCUSSION

Results of infiltration measurement for the paired plots are shown in the Fig 6. The χ^2-test was employed to determine the significance of the sowbug activities in enhancing the infiltration rate.

The calculated chi square was 111.45 which is more than the Chi-square at the 5% level (111.445>23.21).

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

Where:

O_i = Sowbug

E_i = Without sowbug (Check)

$$\chi^2(5,10\%)=18.03 \qquad \chi^2(1,10\%)=23.209$$

$$\chi^2 = 111.446^{**}$$

The t-test was also used to ascertain the significance of the sowbug in increasing the infiltration rate; it was significant at the 1% level.

Extending the economic life of the artificial recharge of groundwater systems is a challenge to the planners and implementers of these facilities. The surface geology of most of the flood-producing watersheds makes their runoff highly turbid therefore, very large sedimentation basins have to be incorporated into the design. However, the presence of very fine particles particularly clay minerals such as chlorite, palygorskite and smectite cause rapid clogging of these basins and infiltration ponds. Although, root channels enhance percolation, infiltrability of the basins and ponds is highly decreased by crust formation.

Floodwater spreading in Gareh Bygon plain make a good condition for creatures. Invasion of the sowbug to the ARG systems in the Gareh Bygone plain in 1993 changed the picture. These crustaceans which sometimes make up to 10 burrows per m^2 with depths down to 185 cm

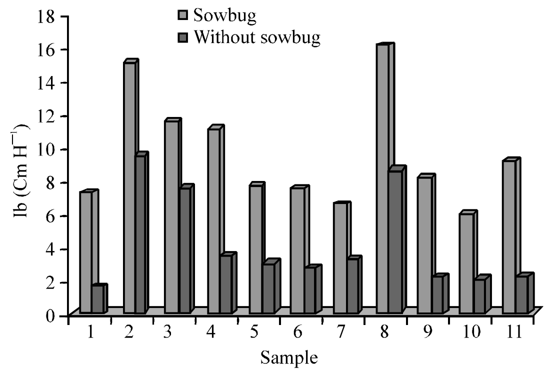

Fig. 6: The effects of sowbug on soil infiltrability rate in Gareh Bygone floodwater spreading system (Sowbug: 7.3, 15, 11.5, 11, 7.65, 7.56, 6.51, 16, 8.1, 6 and 9.1; Without out sowbug: 1.7, 9.5, 7.4, 3.4, 3, 2.8, 3.2, 8.6, 2.2, 2 and 2.2)

Table 1: The t-paired test and statistical parameters for compared mean infiltration

	Mean	SD	SE	95% CI Lower	95% CI Upper	T	df	Sig.
Sowbug -check	5.429	1.427	0.430	4.470	6.388	12.616	10	0.000**

Table 2: The effects of sowbug on infiltration in the Gareh Bygone floodwater spreading, (mean±SD)

Parameter	With sowbug	Without sowbug	Significant
Infiltration	9.61±2.86^a	4.18±3.38^b	**

have increased infiltration rates up to 4.2 fold in some plots. Sowbugs increased infiltration rate about 2.5 fold in average (Fig. 6). Table 1 and 2 shows that showbug increase infiltration rate in comparison with control and show a significant difference in 1% level.

CONCLUSION

The study show that as sowbugs feed on quailbush, it seems prudent to introduce this browse plant into the systems, even for the sole purpose of attracting the sowbugs. Needless to say, this plant can support four sheep the year round if planted at a density of 625 bushes ha^{-1}, quite a feat for a sandy desert. Domestication of this organism, a souvenir of the ARG systems, seems technically practicable, environmentally sound, economically feasible and socially acceptable.

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