

Ecology, behaviour and management of black harvester ant *Solenopsis richteri* (Forel) in Hamelmalo, Eritrea

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Summary

The black seed harvester ant, *Solenopsis richteri* Forel (Hymenoptera; Formicidae), is one of the most serious pests of crops and grazing areas in the sub-zone Hamelmalo. A study on the harvester ant was conducted with the objectives of understanding its ecology, behaviour, and host types and assessing the damage caused by the pest. The ecology and behaviour assessments were done by observing the type and distribution of the nest, time of foraging, nest cleaning, and patrolling for foraging and mating. In addition, observations were made on the types of hosts and loss assessment using bio-pesticides and some selected insecticides on the bare area around the ant nest that was replicated in space. The outcome revealed that the ant constructs underground nests in open grassland and field crops that are devoid of trees and shrubs. The ant nests were distributed about 25 meters apart from each other, with a bare land area of 30-60m² around their nest. The ants were actively foraging during the cold time of the day and during the night when the temperature was cool. The ants affect the crop at different stages by collecting the seeds during sowing and cutting the seedlings after germination and crop maturity. Its preferred hosts are grass seeds and crops, followed by small animals like termites, bugs, worms and seeds of some weed species. The harvester ants in the study area caused yield loss of 24-32Q per hectare and reduced the forage of the grazing areas for livestock.

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Introduction

Ants are social insects belonging to the family Formicidae and to the order Hymenoptera that have colonized almost every space of land. They live in colonies that range in size from a few individuals to millions and have cast systems as queen, male and workers. The primary duty of the queen is to lay eggs up to 1500 eggs per day. Within the worker class, there are several occupations that each will perform, such as nest maintenance worker, midden worker, forager, and patroller/scout (<http://www.greensmiths.com/ants.htm>, <http://www.lingolex.com>, <http://www.infowest.com>). The genus *Solenopsis* is native to central South America, the state of Mato Grosso in Brazil. It has been reported in the U.S. and Australia (Queensland, near Brisbane), Antigua and Barbuda, Bahamas, the British and U.S. Virgin Islands, Cayman Islands, Hong Kong, Malaysia, Singapore, Taiwan, Trinidad and Tobago, and the Turks and Caicos Islands (Marone et al. 2000, ISSG 2006). *Solenopsis* ants build different types of mounds or nests that are used as nurseries, food storage and resting places. The nests of ants are made up of galleries and chambers that are found underground, excavated under stones, logs, decayed trees, hollow twigs or thorns (<http://www.everythingabout.net/articles/biology/animals/arthropods/insects/ant/>). *Solenopsis* ants are termed

industrious, although the intensity of activities in a colony varies at certain times of the day. In the tropics, for example, the colonies are most active in the morning and night when the temperatures are cool. During the extraordinary times of the day, the workers are most active in collecting and storing food. However, during the high temperatures of the day, they remain within the nest to avoid the heat (<http://www.everythingabout.net/articles/biology/animals/arthropods/insects/ant/>).

The harvester ants have been named so that they can harvest seeds of different field crops and grasses. Their abundance and varied ecological role make them influential in agricultural ecosystems around the world (Holldobler & Wilson 1990; Haldhar et al. 2020). Seed harvester ants rely heavily on seeds, which account for 87-94 % of the items carried to the nest. Harvester ants remove the plumule of seeds so that the seeds may not germinate in their nests and can be stored as food for a long time (Adams et al. 1976). After consumption, the hard seed coats are thrown out of the nests and can be noticed in abundance around their nests. The presence of harvester ants can be easily spotted in agricultural fields, gardens, parks or lawns, where they create corridors or passages on land which look like passages created by repeated movements of humans on grass lawns (MacMahon et al. 2000).

These ants' clear vegetation forms a large circular pattern of bare ground around their nest. This bare ground is often covered with small pebbles dug from

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within the nest itself. Extending in various directions from the central mound are foraging trails leading to various foraging zones. Near the entrance to the nest is an area called the midden. This area varies in diameter depending on the diameter of the mound itself. The midden is the “trash dump” for the colony. It is where the ants deposit pebbles, dead workers, unusable matter from plants and animals roughed in by foragers, etc (Cole 1994). Ants are both beneficial and harmful to the environment. The benefits of ants include the dispersal of seeds and the improvement of soil conditions in the vicinity of the nests. Wagner et al. (2004) showed that soils within the vicinity of nests of *Solenopsis* contain higher concentrations of organic matter, nitrogen and phosphorus than surrounding soils. This is due to the harvester ants collecting plant materials from the surrounding area and disposing of them within the vicinity of the nests. According to Wilson (1971), ants can act as agents of seed dispersal. Dean & Yeaton (2008), on the other hand, showed the impact of harvester ants in seed distribution in which more seedlings germinated in nest mounds than in inter-mound spaces. Ants can also help control other pests like fleas, caterpillars and termites.

Ants play an essential role in the dynamics of plant communities by acting as seed predation, which may accelerate a rare plant's decline; their influence may become particularly relevant for rare and endangered plant species where high predation rates can have a significant impact on a species' survival (Albert et al. 2005). They can also contribute to land degradation under certain environmental conditions due to their foraging activities that remove the vegetation cover within the proximity of nests (Kiunsi 2010). Heavy and selective grazing may cause different plant species to dominate the plant community, incredibly exotic annuals that were shown to be undesirable to the ants (Brown et al. 1979; Inouye et al. 1980; Usnick 1996; Haldhar SM & Maheshwari, 2021). The ISSG 2006, Kiunsi & Meadows (2006) define land degradation as a process that involves vegetation or soil degradation and the result, which means failure in land productivity. Harvester ants contribute to land degradation in the area through the creation of bare lands. *Solenopsis* ants impact plant species through direct grazing on seedlings but perhaps more significantly via indirect effects due to impacts on insectivorous species and ecological processes such as seed dispersal, pollination and germination (White 2009).

Solenopsis ants cause plant damage by eating fruit and seeds, tunnelling into stems, ring barking seedlings and feeding on nectar. They also consume insects at any stage of development, from egg to adult; they feed on predatory arthropods such as spiders and on other invertebrates, especially those that are solitary (Davis 2003). Harvester ants may control the balance of species within an invertebrate community more than other arthropod predators, which can lead to an overall decrease in insect biomass. The black harvester ants have been reported to attack the eggs or nestlings of several species, including turtles, lizards and water birds. They are associated with a decline in the nesting success of many species. Ants affect species richness and the

abundance of invertebrate individuals in an area, attacking and consuming those invertebrates that do not defend themselves adequately or escape (ISSG 2006; Kiunsi 2010). The black harvester ant *Solenopsis richteri* (Forel) is a significant pest of cereal (sorghum and pearl millet), oil crops (groundnut), vegetables (tomato, okra, and pepper), and pastureland and in the storage of grains in sub-zone Hamelmalo. Johnson, RA. 2000 reported that harvester ants cause direct damage by collecting and storing seeds during the sowing of crops, cutting the seedlings at the early growing stage, and collecting seeds during harvest from threshing fields, which are the primary grain storage pests. The indirect damage is caused by creating clear crop and pasture land areas, forming a large circular pattern of bare ground around their nest. The number of nest/ant mounds is very high, and the area covered by each ant nest/mound is highly variable (4-9 meters in diameter), which causes a reduction in hectares of crop production and pasture lands. To assess the impact of the ants, a study was conducted in the sub-zone Hamelmalo with the objectives of assessing the distribution of the ant nests, identifying their host plants and behaviour and determining the loss caused by the harvester ant.

Materials and Methods

Location

The study was conducted in the sub-zone Hamelmalo in the Anseba region. Hamelmalo is located northeast of Keren, about 13 km from the road Keren to Afeabet. The sub-zone is semi-arid with a mean annual rainfall of 450mm and has a sandy loam soil type.

Behaviour

A study on the behaviour of *S. richteri* was assessed in 10 selected ant nests (5 each from farmland and grazing areas) at a different time of the day. The study was conducted at the time of the day when the ants were active for harvesting, cleaning the nest, patrolling or scouts, travelling long distances, and identifying preferred areas for foraging.

Distribution

A survey on seed harvester ants was conducted in all the crop production areas and pasture land/grazing areas of the sub-zone. The survey was conducted in 9 villages (Table 1). During the survey, 20 crop fields and ten grazing/pasturelands were taken randomly from each town. The area for the farmland varies from 0.25 to 0.75ha, while the area of the pasture land/grazing was half a hectare each. In each study (crop field and grazing) area, the survey was conducted along the two diagonals of the plots and the mid-long axis of each field. Ant nest count/assessment was done at an interval of 15 meters. At each point, the nest count or bare lands were located and recorded; the diameter of the bare land around each nest was determined. In addition, the distance between nests and the foraging distance from the nest was assessed and measured.

Host Plants of *Solenopsis richteri*

A survey of host plants of *S. richteri* was conducted in selected farm plots and grazing areas of the sub-region. Ten and eight ant nests were selected from farm fields and grazing areas, respectively. Around each ant nest in both cases, observations were made on the direct

collection of items from returning foragers; at least 20 foragers' ants with their loads were collected with forceps and a teaspoon at each colony on every sampling occasion. Each collected item/plant sample was assessed and categorized as stem, leaf, flower, fruit or seeds and their respective species were determined. In addition, the midden (trash dump area) of 12 ant nests (six each from crop field and grazing) were examined for disposal of hard seed coats or husks of different plant species that are thrown out of the nests. Besides, direct observation was done on standing grasses, seeded/sown fields, and crops during harvesting of the ant. In field conditions, the host plants were recorded. Assessment of host plant seeds was also done inside the ant nest after digging 1 to 2 ant nests in each survey area. In all cases, the seeds collected from foragers and direct harvest ant nests were counted and identified. Seeds that were difficult to locate were planted in pots in the laboratory and allowed to grow up to flowering for identification.

Loss assessment

The loss assessment trial was conducted at the Hamelmalo Agricultural College field trial site during the cropping seasons of 2015 and 2016. The trial was conducted in a randomized block design replicated five times in space (different farmers' fields). Five treatments comprise Chlorpyrifos granule, Carbofuran granule, neem and *Jatropha* (*Jatropha stenoncephalla*) seed aqueous extracts and untreated nests. For each treatment, five ant nests approximately the same size (42m²) and the same seeding/sowing date were used at random in the area. The data collected were germination date and seedling stand count at 15 and 25 days after seeding from each plot. Other information collected were agronomic data such as date to heading, maturity and yield per plot.

Treatments

The whole bare land around each ant nest (42 m²) was used as a plot. Sorghum seed was used at the rate of 12 Kg/ha. Fertilizer Diammonium phosphate and Urea were applied to each plot as recommended for the area. Chlorpyrifos and Carbofuran granules mixed with sorghum grain were each sown on a plot at a spacing of 70cm and 10cm between rows and plants, respectively. Likewise, neem and jatropha aqueous extract solution-treated sorghum grains were prepared and sown in their respective plots. No pesticide treatment was applied to the control ant nests. In order to have an efficient control of each pesticide, 5gm bait was prepared from a mixture of grain sorghum, granule, or bio-pesticides, 5gm of sugar (as attractant to the ant) and then moistened with water. The bait for each pesticide was applied/ spread around the ant exit hole and along the path of foraging ants in each plot or ant nest. All the treatments in all the replications were applied at about 6:30 pm before the ants were out of their nest for foraging and to avoid birds and other organisms collecting the baited seeds. The following day, at 10:00 am, samples of dead ants were collected and counted from an area of 10 x10cm from the exit hole and along the path of each plot.

Statistical analysis

Data collected on different parameters were analyzed using the statistical software Genstat, and mean comparisons were performed using the least significant difference (LSD) at a 5% level of significance.

Results and Discussion

Ecology, behaviour and distribution

The harvester ant (*Solenopsis richteri*) is a subterranean colony found in open fields that are free of trees and shrubs. Usually, they prefer open grassland or arid habitats. The ants were observed building underground nests in an open place devoid of trees and shrubs in farmlands and grazing areas. The nests in the study area were primarily constructed in drained sandy loam and sandy clay soils. In some new nests, the workers were noticed to alter the area peripheral to the nests by clearing away the plants, bit by bit, with their powerful mandibles to get full sunlight. During the survey, no ant nests were found in areas covered by acacia trees or bushes. This could be due to the trees and bushes' canopy not allowing the penetration of sunlight into the soil; as a result, under these conditions, grasses, which are the leading producers of tiny seeds, do not grow.

In the Hamelmalo area, the nests of ants are made up of galleries and chambers that are found underground at a depth of 1-3 meters with one primary and many small exit holes for harvesting and cleaning the nest. The small exit holes, most of the time, are closed or filled with small pebbles and soil; they are opened and used for emergency purposes, such as during flooding or when pesticides are applied selectively to the entrance hole. In this case, the central entrance/exit hole is closed to keep away the pesticides, flooding and other hazards. The small ones which were not treated with pesticides are opened when the main exit is closed. The ant nests were easily spotted in agricultural fields or grazing areas where ants create bare land free of any plants. The bare land is created by workers killing the existing plants and clipping seedlings on the mound or preventing plants from growing around the nest sites while the colony is alive. Ants deposit seed husks and other organic debris onto the surface of the nest mound in small piles, or midden, that shift in position throughout the active season. Beattie & Culver 1983; Li 2008 reported that *S. richteri* clear vegetation, forms a large circular pattern of bare ground around their nest, which is in line with the present finding. Adamset al. 1977; Crist & MacMahon 1991 gave a similar report that *S. richteri* prefers open grassland and bare areas that are free of trees or shaded areas. He also explained that bare ground is often covered with small pebbles dug from within the nest itself. Extending in various directions from the central mound are foraging trails leading to various foraging zones.

Behaviour

The harvester ant (*S. richteri*) in the study area was primarily active from 4:30 pm the afternoon to 10:00 am the next day during the months of July-November. In contrast, during the dry months of December to June, the ants were active from 7:00 pm to 5:30 am when the temperature was cool. *S. richteri* is group-foraging

species; workers exit the nest in a column or along a trunk trail and break off to forage solitarily at the distal end of the column. The workers actively recruit nest mates to seed patches, thus facilitating rapid harvest of localized resources. During the hottest time of the day, ants remain within the nest to avoid the heat or high temperature. Park et al. 2004 reported that harvester ants in the tropics are most active in the morning and night when the temperatures are cool. During the extraordinary times of the day, the workers are most active in collecting and storing food. Similarly, Hill, 1975 reported that the ants were active from early in the morning to about 11:00 am and late in the evening when the temperature was low. At noon, when the temperature was hot, there was no ant activity. During the hot months, the ants plug the entrance/ exit hole to their nest with pebbles early in the morning at about 5:30 am; no ant movement is observed during the hot temperature of the day except the nest patrollers that come out at an interval of 5-10 minutes. These frequent come-out-of-the-nest patrollers could be to monitor or check the heat (temperature) of the outside. Stoddart et al. 1975 also reported that the activities of harvester ants in the tropics are limited during the high temperatures of the day to avoid the heat. Pirk et al. 2004 in Argentina reported that when the temperature started to cool down, the scout ants, the nest maintenance, and cleaners came out of the nest and started their activity. At the same time, the patroller ants come out of the nest to find and locate the source of food or seed. Once the patrollers identify the position of the food, then they head straight back to the nest, leaving a chemical trail (pheromone) on the plant or source of food as well as on the track back to the nest. The patrolling/scouting ants inform the foragers where the source of the food is, including the distance from the nest. Based on the patrollers guide, the foragers followed the marked track to reach the source and collect the seeds. The foraging ants only emerged from the nest once patrollers/scout ants returned to the nest. Once the colony started to forage, it continued until it found food to take back to the nest, and when the rate of foraging was fast, it indicated that food availability was very high. On the other hand, a decline in food availability was suggested by a decrease in foragers' return rate and decreased foraging activity. Kiunsi 2010 and Cole 1983 reported that ants in the tropics are active during excellent times of the day and at night in collecting and storing food.

Mating

Harvester ant *S. richteri* has colonies that include the queen and different groups of workers such as nest maintenance workers, midden workers, patrollers and foragers. Reproduction of the new colony started with the onset of the rain, mainly during the rainy months of June and early July. Holldobler and Wilson, 1990, studied the biology of ants and reported that mating flights occur after 2–3 days following sufficient rain, with alates leaving the nest at about 4:00 pm. The winged/alate reproductive males and females mate in the swarm. Once the female alate had mated, she raked her legs to break the wings off at the basal suture and then walked to search for a place to dig a nest. Often, the preferred

nesting spot is grassland, the edge of a sidewalk, or farmland. According to Holldobler 1990, the queen excavates a small chamber to burrow into the soil, which is the same as the present study. Davis 2003, studying ant biology, found that the queen is the single producer of eggs and is capable of producing as many as 1500 eggs per day. Most of the eggs devolved into workers and served to perform all the tasks necessary to maintain the colony.

Distribution

The survey results showed that all the farms and grazing areas in the sub-zone had ant nests with bare land where there was no crop or grass production in these bare lands. The number of ant nests varies from 20 nests per hectare at Wazentet to 30 nests/ha at Libna, with an overall mean of 25.8 nests/ha Table 1.

The area of the bare land was variable from village-to-village farmlands. The most extensive bare land was recorded at Libna, with an area of 80m², and the lowest bare area was observed in the village Wazentet, which had 26m². The mean bare land area due to the impact of the ants in the study villages was 43.2m². At Libna, the number of bare lands and its area were high due to the soil in this village being sandy loam, and the town has more flat lands both for grazing and farmlands. In contrast, in Gizgza the city is hilly and has more rock or graveled grazing lands which might not be preferred for ant nest construction and habitat. The percentage of bare land per hectare was very high, varying from 5.2 to 13.9, with a mean of 11.4. This result indicates that a considerable amount of farmland is lost from production due to the construction of nests and clearing of any plant from germination. This is in terms of grain loss, but the ants also affect the biodiversity of the grazing by decreasing species richness. Samson et al. 1992 in Arizona reported a similar result where the harvester ant caused a bare land area of 15.5% per ha.

During the survey, ant nests were found at scattered places throughout the farms and grazing areas that vary from 22 to 30 meters, with a mean of 27.7 meters between the nests. The distance between the nests could have been more consistent depending on the distribution of forage or grass for harvesting seeds. Adam et al. (1977) and Johnson (2001) also reported that the distance between nests varies depending on the biodiversity of forages and the age of the ant species in the colony. The younger colony built very close nests (Crist & MacMahon 1992). Harvester ants also forage grass seeds and seeds from other plants over a wide area, covering as much as 30% of the total area of rangelands (Stoddart et al. 1975). This may contribute, on a longer time scale, to the loss of the seeded area, hence retarding the regeneration of the rangelands. In this study, it was clear that the farmed area, which had higher human activities and livestock density, was affected more by harvester ants compared to fallow areas and open stony scrub.

The harvester ants travel long distances from their nest to harvest seeds depending on the season and availability and distribution of the seeds. During the months of August to December, the distance for foraging was very short as the grass and crop seeds were easily

accessible around their nests. However, during the dry months, February to June, the area is dry. The crops are harvested, and the grass is also grazed both by livestock and the ants; hence, the ants have to travel long distances. In general, the ants travel for foraging 30 meters during seasons of high food availability to 105

meters during the dry season when the seed or grass and other harvestable materials are scarce. During the study, it was observed that the distance and direction of foraging ants were adjusted such that they were channelled away from hostile neighbours' Table 1.

Table1. Distribution of harvester ant *Solenopsis richteri* per ha, area of ant nest, % bare land, distance between nests and foraging distance from the nest

Village	Number of ant nests/ha	Area of bare land in m ²	% bare land/ha	Distance between nests in meter	Foraging distance in meter
Hamelmalo	25	45	11.3	30	55
Wazentet	20	26	5.2	36	50
Gonfolom	27	50	13.5	22	75
Tsebab	29	48	13.9	25	65
Libna	30	60	18.0	28	30
Basheri	22	40	8.8	24	105
Gizgiza	28	47	13.2	29	85
Fredarb	25	38	9.5	25	95
Berekentya	26	35	9.1	30	60
Mean	25.8	43.2	11.4	27.7	68.9
SE±	3.25	5.1	4.21	2.11	6.71

Host plants and animals

Harvester ants feed on seeds of different plant species, termites and other small animals that differ from species to species depending on food habits that can be classified as carnivorous, herbivorous and omnivorous Mueller et al. 2005. The harvester ants have been named so that they harvest the seeds of different field crops and grasses, and their main menu (87-93%) consists of grass seeds. During the study, it was observed that *S. richteri* harvested about 20 species of grasses, 19 species of weeds (broad-leaved plants), crop grains and small animals Table 2. Among the grass species, the most commonly harvested were *Aristida*, *Eragrostis*, *Panicum*, *Setaria*, and *Digitaria*. Likewise, among the weed species, the most widely harvested were *Cassia*, *Chenopodium*, *Amaranthus*, *Crotalaria* and *Acanthospermum*. The chaffy of these grasses and weeds were widely observed on the middens of the ants. A 17-year study of the harvester ant in Arizona also revealed that ants have a particular affinity for needle grama (*Bouteloua aristidoides*) (Samson et al. 1992). Other researchers have recorded them gathering love grass (*Eragrostis* sp.), panic grass (*Panicum* sp.), crabgrass (*Digitaria* sp.), buffalo grass (*Buchloe dactyloides*), and three-awn (*Aristida* sp.). Suzanne Tuttle at the Fort Worth Nature Center and Refuge has noted harvester ants collecting Texas grama (*Bouteloua rigidiseta*) (Moody & Francke 1982; Taber 1998). Marone 2000; Mueller et al. 2005 and Crist & MacMahon, 1992 reported that harvesters gather seeds from plants outside the grass family like pine (*Pinus* sp.), ragweed (*Ambrosia* sp.), pokeweed (*Phytolacca* sp.), palmetto (*Sabal* sp.), nettle (*Urtica* sp.), evening primrose

(*Oenothera* sp.), bluebonnets (*Lupinus* sp.) and mormon tea (*Ephedra* sp.).

The grains of the most commonly grown crops of the area, such as pearl millet, sorghum, and groundnut, were also noticed to have been harvested by the ants in all the surveyed areas. Farmers in sub-zone Hamelmalo of Eritrea reported their grains were harvested mainly during the planting time just before germination during June/July and later at maturity of the crops during October/November, mainly from lodging plants and fallen grains after bird damage. In addition, the farmers also reported that the ants had nests near the residents of the farmers, collected grains from stores and acted as storage pests in the area.

Though *Solenopsis richteri* are primarily seed-eaters, they also harvest animal matter as well. Some ants in the tropics are carnivorous and feed on insects found along their travel path, including lizards, snakes, scorpions, lice, screwworm maggots, ticks, mites, snails, worms, millipedes, silverfish, spiders, grubs, beetles, other ants, termites and small insects (<http://www.infoplease.com/ce6/sci/A0856629.html>, <http://www.everything2.com/>).

During the host species study, it was observed that the ants harvest adult winged termites during and after the rains in June and July. In addition, it was widespread to observe that the ants carry worms of Lepidoptera, Coleoptera, cricket, snails, millipedes and dead lizards. According to Marone 1998 and Mueller et al. 2005, ants cut the lizard and big Arthropod bodies into pieces with their robust mandible and then carry them to their nest.

Table 2. Host plants of harvester ants (*Solenopsis richteri*)

Host plant	Host plant
Poaceae	
<i>Aristida funiculata</i>	<i>Echinochloa tolona</i>
<i>Acrachnnera cemora</i>	<i>Erigeron karvinskianus</i>
<i>Brachivriareptans</i>	<i>Hetropogon contortus</i>
<i>Brachiarasp</i>	<i>Panicum maximum</i>
<i>Chloris inflata</i>	<i>Panicum flavidum</i>
<i>Cyndon dactylon</i>	<i>Penisetum cenchroides</i>
<i>Digitariabricornis</i>	<i>Perotisindica</i>
<i>Digitarialongiflora</i>	<i>Setariaverticiliata</i>
<i>Dinbera Arabica</i>	<i>Setariaglauca</i>
<i>Eragroststennela</i>	<i>Targus roxburghis</i>
Broad-leaved weeds	
<i>Biden pilosa</i>	<i>Amaranthusspp</i>
<i>Culutropisgigantea</i>	<i>Alternatherapunggens</i>
<i>Cassia nigvican</i>	<i>Acanthospermumhispidum</i>
<i>Cassia occidutalis</i>	<i>Tribuluterrestris</i>
<i>Chenopodium unbrosioides</i>	<i>Tophrosiapurpurea</i>
<i>Cenchrus ciliaris</i>	<i>Lantana camara</i>
<i>Cleome chelidonii</i>	<i>Ocimumcarnum</i>
<i>Corchrusoli forius</i>	<i>Leucashirta</i>
<i>Crotalaria veruucosa</i>	
Crops	
<i>Sorghum bicolor</i>	<i>Arachishipogaea</i>
<i>Pennisetum glaucum</i>	<i>Elevsinecoracana</i>
Animals	
<i>Termites</i>	<i>Grasshoppers</i>
<i>Bugs</i>	<i>Worms</i>
<i>Cricket</i>	<i>Reptiles</i>

Type of seed stored in an ant nest

The harvester ant *Solenopsis richteri* constructs an underground nest at a depth that varies from 1-3 meters or more depending on the type of soil. The ants process and store seeds at different depths of the nests. It was observed that the seeds with their chaffy or husks were stored in the first 30-90cm, while the old seeds free of husk or chaffy were stored at lower depths (more than 90cm). It seemed the less preferred hosts were stored at shallow depth while the most preferred hosts (sorghum, pearl millet, *Eragrostis*) were stored at lower depth Table

3. During the study, it was observed that the seeds had different germination rates. The weed species such as *Amaranthus*, *Lantana* or *Trophosia* had lower or no germination, while all the *Poaceae* groups had high germination rates. However, the rate of germination of these species decreased with the nest Table 3. It is a common practice in Eritrea, where farmers dig or destroy ant nests to collect seeds of cereals or pulses during drought periods and when they are short of seed as a source of seeds.

Table 3. Types of seeds, number of seeds and per cent seed germination at different depths of an ant nest

Depth of the ant nest(cm)	Host seed	Mean Number of seeds	Germination %
30	<i>Cassia spp</i>	49*	0
	<i>Amaranthus pp</i>	193	25
	<i>Tophrosia spp</i>	270	9
	<i>Lantana</i>	135	21
	<i>Eragrost spp</i>	711	80
90	<i>Cassia spp</i>	20	0
	<i>Acanthospermumsp</i>	211	12
	<i>Digitaria spp</i>	650	19
	<i>Aristida</i>	971	90
	<i>Sorghum</i>	901	90
	<i>Pearl millet</i>	1235	90

168	<i>Cyndon dactylon</i>	1201	25
	<i>Panicum spp</i>	785	20
	Pearl millet	1001	87
	sorghum	1210	85
190	Pearl millet	921	75
	<i>Eragrostis spp</i>	890	50
	sorghum	785	75

*Mean number of seeds counted per nest

Pest management

There was a significant difference among the treatments used for the control of *S.richteri* in Hamelmalo. The best

results were obtained from Chlorpyrifos and Carbofuran treatments followed by Jatropha seed extract Table 4.

Table 4. Efficacy of insecticides and bio-pesticides on harvester ants and yield of sorghum, 2015

Treatments	Rate PerPlot	Number dead ants/100cm ²	Stand count days after seeding		Heading date	Maturity date	Yield Q*/ha
			15	25			
Chlorpyrifos	8gm	1054	65	85	65	80	28.32
Carbofuran	8gm	895	67	92	67	78	32.05
Neem	40ml	30	25	10	70	83	6.01
Jatropha*	40ml	205	45	50	67	82	8.31
Control		0	10	1	0	0	0
LSD		195.73	15.23	21.15	5.35	4.71	15.01
CV%		18.53	12.31	16.32	10.02	17.11	9.81

1 quintal=100kg; *Jatropha *stenocephalla*

Chlorpyrifos and Carbofuran gave a higher number of ant control, higher germination, and seedlings that stood at 15 and 25 days after seeding. In addition, the two treatments gave higher yields of 28.32 and 32.05 Q/ha for Chlorpyrifos and Carbofuran, respectively. The plant extracts of Neem and jatropha yielded 6.01 and 8.31Q/ha, respectively. However, these yields from plant extract are pretty low when compared to the insecticides used. No yield was obtained from the control plot because the ant harvested the seeds before germination, and later, the seedling was cut at soil level and destroyed by the ants Table 4. The results of 2016 are similar to that of 2015. Again, in 2016, both insecticides yielded the highest yield compared to the control plot and plant extracts. Chlorpyrifos and Carbofuran granules used gave the highest number of dead ants and seedling stand counts at 15 and 25 days after seeding/planting Table 5. In 2016, the highest yields, 26.12 and 24.25 quintals per hectare were obtained from plots treated with Carbofuran and Chlorpyrifos, respectively. Plant extracts

of neem and jatropha yielded 5.35 and 9.25 quintals per hectare, which is much lower than that of granular insecticides. No yield was harvested from the control plot Table 5.

Various methods have been employed to manage harvester ants in different parts of the world. Davis JM 2003; Crist and MacMahon, 1992 working on the control of harvester ants, found that uses of fibrinol and permethrin resulted in higher ant control and the ants were eradicated from the farm area. Similarly, Cole1994, reported that bait was used both for individual and broadcast applications around the nest, and the foraging gave efficiency to reduce the ant population and the bare area in the farmlands. In other studies conducted by Pirk et al., 2004, using pressurised insecticide drilling to the mound was effective in controlling the pest. However, it is essential to remember that insecticides are hazardous to human beings and also affect non-targeted organisms. They should be used wisely and with great care Davis 2003.

Table 5. Efficacy of insecticides and bio-pesticides on harvester ants and yield of sorghum, 2016

Treatments	Rate	Number dead ants/100cm ²	Stand count days after seeding		Heading date	Maturity date	Yield Q/ha
			15	25			
Chlorpyrifos	2kg/ha	975	63	80	67	75	24.25
Carbofuran	3kg/ha	934	73	85	69	81	26.12
Neem	3lt/ha	15	21	8	72	79	5.35
Jatropha	3lt/ha	175	31	45	70	80	9.25
Control		0	19	1	0	0	0
LSD		251.3	21.32	30.12	3.58	4.76	13.36
CV%		20	17.32	11.12	10.21	13.45	15.24

1 quintal=100kg

Conclusion

Solenopsis richteri Forel is native to South America and has become an invasive ant in Eritrea. It is distributed in the semi-arid areas of Eritrea and affects both field crops as well as grains in stores. Under field conditions, crop damage is caused by the direct collecting of seeds during seeding/sowing, cutting seedlings grown around the mound/nest, and harvesting grain at the maturity of the crop. In addition to this, it makes a wide spot of bare land, about 20-30 mounds per hectare, with a diameter of 4-9 meters per bare land. The bare land around the mound decreases the farmland, and so also decreases crop production and productivity. The ant has a wide range of hosts, both from plants and animals, with 20 and 7 species, respectively. The black harvester ant in the study area, in general, causes about 24-32% yield reduction. Insecticides of different formulations efficiently manage the colony of the harvester ant; however, one should note that pesticides are harmful as they affect the environment and non-targeted organisms.

Declaration of Interests

The authors have no conflict of interest to declare.

Data Sharing

All relevant data are within the manuscript.

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