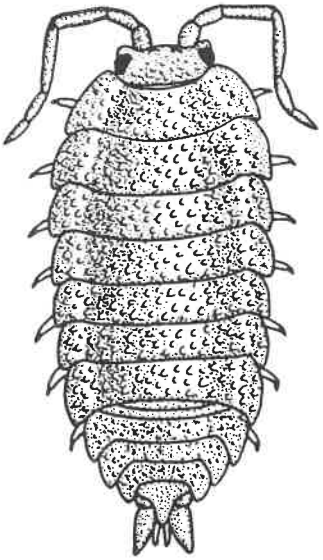
INVERTEBRATES

Status: Introduced

PILLBUGS

Description

Pillbugs, also known as sowbugs, or woodlice, are familiar backyard creepy crawlies to most of us. Pillbugs are correctly classified as terrestrial *Isopods*, and belong to the Class Crustacea. Familiar *crustaceans* include lobsters, crabs, shrimp, and daphnia (water fleas). The *crustaceans*, in turn, are part of a larger group, Arthropoda, or jointed-legged animals. All *arthropods* have a tough outer *cuticle*, a trunk divided into segments, and limbs which, because of their stiff *cuticle*, articulate about flexible joints.



Pillbugs are easily recognized by their flattened or round-backed profile, seven pairs of legs, and sharply-angled *antennae*. Some species are able to roll into a ball when disturbed, hence the name, pillbugs. The broad head has 4 pairs of mouthparts and is followed by the 7 main trunk segments, which bear the walking limbs. Behind these are 6 smaller segments comprising the pleon. The pleon segments also carry limbs, but these are greatly modified. The first 5 pairs are the *pleopods*. These are flattened and form a set of overlapping gills visible on the underside of the animal. They have many functions including reproduction, gas exchange, and excretion. In some species the *cuticle* of the *pleopods* is in-folded, creating whitish, branching tubules that constitute pleopodal lungs. The final pair of appendages, the *uropods*, project from the rear of the animal and are sensory and defensive in function.

There are about 12 species of pillbugs found in the northern and central United States. Several other species are found in coastal *habitats* and in the Florida wetlands. Only 4 species have been recorded from South Dakota. These are superficially similar, but can be separated easily with a hand lens. With

practice, they can readily be distinguished with the naked eye.

Cylisticus convexus, our only species that is capable of rolling into a ball, has a top surface that is a dark, glossy, gray-black marked with pale, translucent streaks. Five pairs of pleopodal lungs are visible as pale patches on the outer margins of the *pleopods*. These pillbugs are 0.3 to 0.5 inches (8-12 mm) in length.

Porcellio spinicornis is a broad, flattened species. The markings are characteristic: the head is dark brown and the back is marked with a dark central stripe, flanked by 2 rows of yellow spots on a pale background. The first two pairs of *pleopods* possess pleopodal lungs. *P. spinicornis* is 0.4 to 0.6 inches (10-15 mm) in length.

Porcellionides pruinosus is a rather slender species, light gray in color with whitish legs, and a characteristic surface bloom like a fresh plum. The *antennae* are long and have distinctive white joints. The first two pairs of *pleopods* possess pleopodal lungs. This species is 0.2 to 0.4 inches (6-11 mm) in length.

Trachelipus rathkei is the most common species in many areas. Color varies from rusty brown to dark gray. Moderately broad and flattened, this species frequently rolls into a "C" when disturbed. As with *Cylisticus convexus*, there are 5 pairs of pleopodal lungs. *T. rathkei* ranges from 0.3 to 0.6 inches (8-15 mm) in length.

Distribution

There is no formal recording scheme for *isopods* in South Dakota. Consequently, information on their distribution is sparse. However, I have found *Trachelipus rathkei* in every South Dakota town that I have visited, and both *Cylisticus convexus* and *Porcellionides pruinosus* appear to be generally common. Thus far, I have only found *Porcellio spinicornis* in isolated localities in Aberdeen and Sioux Falls. More recordings would be valuable!! It is very likely that all of these species are widespread in the state and other species probably await discovery.

One reason for the scant records of pillbugs throughout North America is that all of the common inland species are actually European introductions. Available records indicate that most species reached North America in the early 19th century. Genetic studies by Dr. Ronald Garthwaite and co-workers at the California Academy of Sciences show the Mississippi and St. Lawrence Rivers to have been the major routes of colonization, strongly suggesting that introductions were brought about through the lumber trade. In the past century the extensive movement of freight via road and rail has probably contributed to the dispersal of pillbugs. This is obviously an on-going process and additional species are likely to colonize South Dakota in the future.

The relative scarcity of *Porcellio spinicornis*, despite an abundance of apparently suitable habitats, suggests a recent introduction. All of these species are strictly associated with human habitation and have probably colonized South Dakota within the last century.

Natural History

Pillbugs can be searched for in any sites that provide locally humid retreats during the day. Compost piles and leaf litter frequently have rich populations, and large numbers can often be found beneath logs and among rubble piles. *Trachelipus rathkei* is particularly common beneath fallen wood or peeling bark. *Porcellio spinicornis* is almost always associated with limestone or cement (also rich in lime) and should be searched for in rock piles, walls, or at the bases of stone buildings. *Porcellionides pruinosus* and *Cylisticus convexus* are quite general in their choice of habitats, but are seldom found far from buildings. All species are *nocturnal* and may venture over considerable distances

during the night. On humid evenings, they can often be seen in large numbers with the help of a flashlight. Pillbugs feed on dead vegetation, such as wood and leaf litter.

There are nearly 4000 described species of pillbugs and they are the only *crustaceans* to have colonized land with appreciable success. Despite this, they did not evolve the incredible waterproofing *cuticle* waxes of the insects and spiders, and are quite susceptible to drying out. Woodlice kept in low humidities (<50%) will dehydrate lethally within a day. However, they have one remarkable adaptive trick to help them. Once the *humidity* exceeds about 87% they can absorb water vapor from the atmosphere for re-hydration. During *nocturnal* foraging, pillbugs frequently lose a considerable proportion of their body water and can survive up to 30% dehydration. During the day, when they seek out humid retreats, they can absorb water vapor to replenish these losses. When found indoors, pillbugs are usually associated with cold surfaces, such as water pipes and stone slabs beneath exterior doors, where the local *humidity* is elevated. Water vapor absorption takes place across the *pleopods*. Only a few groups of animals share this capacity to absorb water vapor from air that is not saturated with moisture. They include flea larvae, booklice, silverfish, mealworms, and ticks.

Although pillbugs are strongly associated with human habitation in South Dakota, they are common in a variety of natural habitats in their native Europe. Their much more restricted range of habitats in the Great Plains is probably due to climate. Most European species appear to have originated in the Mediterranean, and they have only a limited tolerance of sub-freezing temperatures. None of our species can survive cooling below about 21°F (-6.0°C). Many insects and other *arthropods*, on the other hand, can survive temperatures below -22 °F (-30.0° C) (think of the insect larvae and pupae living beneath tree bark which sustain the tree-creepers and nuthatches over the South Dakota winters!). Survival at such temperatures is made possible by the production of remarkably effective antifreezes to protect the cells from ice formation. In mid-winter, pillbugs would have to burrow more than 24 inches (60 cm) below the ground surface to reach safe temperatures. Since they are not proficient burrowers, this probably eliminates them from most habitats, including the prairie grasslands. Around human habitation, pillbugs can seek refuge from the winter cold in deep crevices at the edges of buildings, in rubble piles, and compost heaps. Artificial heating and the high thermal inertia of buildings also elevates backyard temperatures in the proximity of buildings.

Pillbugs reproduce during the months of May through September. The males possess elongated first and second *pleopods* which are used for fertilization (see Figure 1). Mating is seldom observed, but the male will crawl obliquely across the back of a female and transfer sperm into the genital opening at the base of the *pleopods*. The female then develops a fluid-filled *ventral* pouch, or *marsupium*, into which the eggs are laid. After a few days, the eggs hatch and the juveniles live for several hours in the *marsupium*, absorbing the fluid and finally breaking free. Initially they have only 6 pairs of legs, but acquire the 7th pair at the first molt. Like all *arthropods*, pillbugs must molt the *cuticle* in order to grow. This occurs every few weeks throughout life. Pillbugs and other *isopods* molt the *cuticle* in separate anterior and posterior halves. Our species live 2 to 3 years.

Significance

Pillbugs form an important component of the larger decomposer fauna, along with earthworms, snails, and millipedes. All of these animals return organic matter to the soil where it is further digested by fungi, protozoans, and bacteria, hence making nitrates, phosphates, and other vital nutrients

available to plants. Although they may occasionally feed on roots, pillbugs do minimal damage to live vegetation and should not be regarded as pests.

Pillbugs are also of importance in sites such as *coal spoils* and *slag heaps*, which face heavy metal contamination. They are capable of taking in heavy metals such as copper, zinc, lead and cadmium and crystallize these out as spherical deposits in the midgut. In this way, they remove many of the toxic metal ions from the soil. Furthermore, owing to their high tolerance of these ions, they thrive where other species cannot, and promote the restoration of contaminated sites by accelerating topsoil formation. This in turn favors the establishment of plants that stabilize the soils by root formation. Stabilized soils reduce problems of toxic dusts and the leaching of metal ions into the ground water.

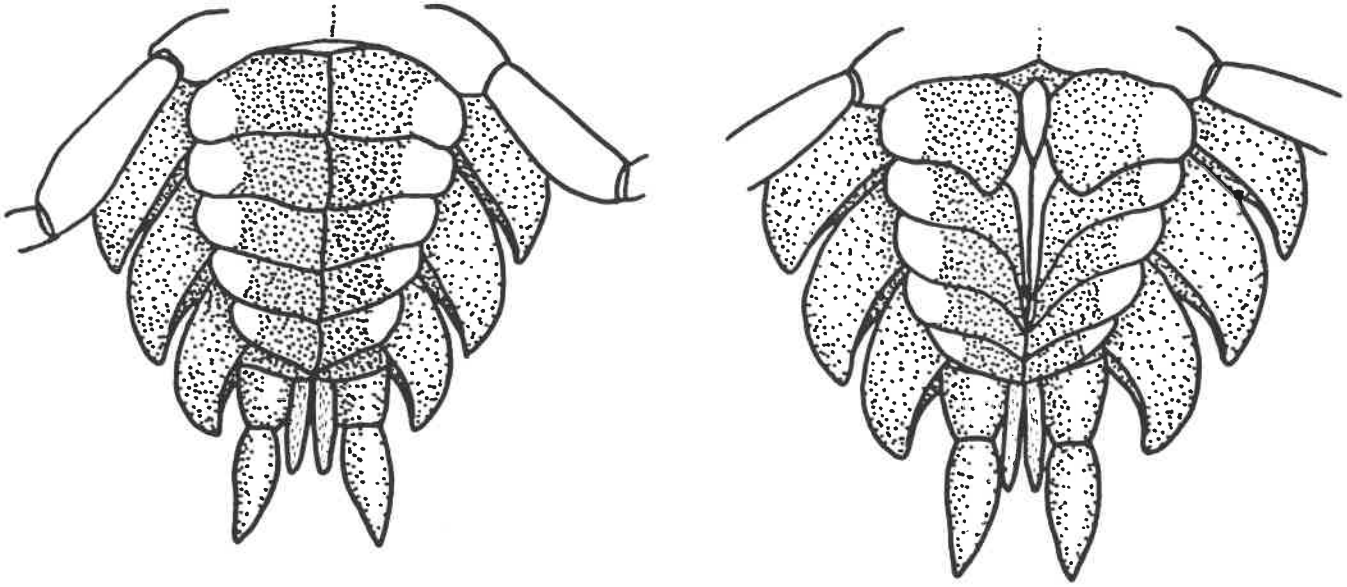


Figure 1. Sexual Differences In Pillbugs - from left to right: *Trachelipus rathkei; T. rathkei*, ventral pleon, female; *T. rathkei*, ventral pleon, male.

Pillbugs In The Classroom

Pillbugs can be collected from suitable habitats during the summer months and transferred to small vials. Plastic film containers make good collecting containers. Maintaining a classroom culture is very simple. Use a small (1.5 liter) container with a lid and maintain high *humidity* by adding moistened paper towels or a small jar of water. Bits of bark and leaf litter provide suitable food. Make sure the chamber is always humid, but be careful to avoid standing water and significant condensation. Under such conditions, pillbugs will reproduce and cultures can easily be maintained for many years.

Pillbugs are excellent animals for simple experimentation. Observe the rates of litter breakdown and conversion to a dark, rich humus. Compare the rates of breakdown of leaves from different plant species. When given a choice of species, are pillbugs selective foragers? Which parts of a leaf are eaten first? Are fresh leaves preferred to old ones? Try some simple behavioral experiments. Using a tray with half of the floor colored white and half black (a choice chamber), see whether pillbugs select dark or light habitats. How do they select their preferred habitat - is it by direct orientation, changes in the rate of movement, changes in the frequency of turning, or a combination of these? You can also study water vapor absorption if you have a microbalance with a resolution of 1 mg. Dehydrate animals to about 20% water loss in room *humidity* then transfer them to a small humidified chamber without food or liquid water. After 5 hours or more, re-weigh the animals and calculate how much water they have recovered. Do the animals show any distinctive behavior or movements while absorbing water vapor?

Pillbugs are also interesting to observe under a low-power microscope (10 to 40 X magnification). See the compound eyes composed of numerous facets (an *arthropod* characteristic), and the numerous minute hairs and cones on the *cuticle* surface, which are actually sensory receptors conveying information (touch, smell) across the stiff *cuticle.* Apply a piece of adhesive tape to the back of an animal and you can then turn it over to study the underside. Note especially the complex *pleopods* and the white, branching pleopodal lungs, and determine whether your animal is male (with elongated first and second pleopods) or female. If the *uropods* are irritated with a mounted needle or a pair of forceps, pillbugs will frequently exude a thick glue which serves to entangle predators, such as ground beetles, centipedes, and spiders.

Glossary

Antennae - the first pair of head appendages in arthropods, primarily sensory in function; feelers.

Arthropod - an invertebrate with a segmented body, paired limbs on each segment, and a stiffened external cuticle. Arthropods contain the largest number of species of any animal phylum. They include insects, arachnids (spiders and relatives), crustaceans, centipedes, millipedes, and some extinct groups such as trilobites.

Coal spoils - earth and rock removed from a mine and dumped on the ground because the coal content is too low to be economically extracted.

Crustacean - a group of arthropods, predominantly marine, with calcium carbonate in the cuticle, primitively 2-branched limbs, and unique segmentation patterns. They include pillbugs, crabs, shrimp, krill, brine shrimp (sea monkeys) and daphnia (water fleas).

Cuticle - the stiffened exoskeleton of an arthropod, composed of protein, the polysaccharide chitin, and sometimes calcium carbonate. It is frequently waterproofed with surface waxes. The cuticle is periodically molted to allow for growth

Habitat - the specific climate, terrain, soil and vegetation which provide suitable conditions for a certain species.

Humidity - a measure of the amount of moisture in the air. Relative humidity (RH; %) is the water content measured as a percentage of saturation (dew point) when condensation begins.

Isopod - the group of crustaceans including pillbugs, all sharing a dorso-ventrally flattened body, 7 pairs of walking legs, 5 posterior gills (pleopods), and formation of the marsupium in females.

Marsupium - the ventral brood pouch developed on trunk segments 1 to 5 of a reproductive female. When full of eggs or newly hatched juveniles, the marsupium forms a conspicuous yellow swelling.

Nocturnal - active at night.

Pleopods - the 5 pairs of flattened gills on the pleon segments. Each pleopod has 2 lobes, the inner (concealed in life) functions in water vapor absorption and nitrogenous excretion, the outer serves in respiration and may bear invaginated lungs. The first 2 pairs of pleopods are lengthened in males and serve in sperm transfer.

Slag heaps - the refuse that is left over from the smelting of metals and often is dumped on the ground in piles.

Uropods - the last pair of appendages in a pillbug. They comprise an outer and inner (smaller) branch from a single basal segment. They function in a sensory capacity like posterior antennae, and can secrete a defensive glue.

Ventral - the underside or belly of an animal.

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Selected Resources For Teachers

Creepy Crawlies and the Scientific Method by Sally Kneidel, Fulcrum Press, Golden, CO.

Pet Bugs: A Guide to Catching and Keeping Touchable Insects by Sally Kneidel, Wiley and Sons, New York, N.Y.

The Pillbug Project: A Guide to Investigation by Robin Burnett, National Science Teachers Association, Wash., D.C.

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