# *Laevicaulis* spp.*

*In April 2013, the family Veronicellidae, a target on the 2013 and 2014 AHP Prioritized Pest Lists, was broken down into six genera of concern, including *Laevicaulis* spp. Information in the datasheet may be at the family, genus, or species level. Information for specific species within the genus is included when known and relevant; other species may occur in the genus and are still reportable at the genus level.

Portions of this document were taken directly from the New Pest Response Guidelines for Tropical Terrestrial Gastropods (USDA-APHIS, 2010a).

*Information for specific species within the genus is included when known and relevant. Other species may occur in the genus and are still reportable at the genus level.

**Figure 1.** 4.5 cm (1 $^{3}/_{4}$ in) small (full length) slug *Laevicaulis alte* (Férussac, 1822) (Michal Maňas, wikipedia.org).

## Scientific Names

*Laevicaulis alte* (Férussac, 1822)
*Laevicaulis natalensis brauni* (Simroth 1913)
*Laevicaulis stuhlmanni* (Simroth 1895)

**Figure 2.** 4 cm (1 $^{9}/_{16}$ in) small (full length) slug *Laevicaulis alte* (Férussac, 1822) (Michal Maňas, wikipedia.org).

**Synonyms:**

***Laevicaulis alte***
*Vaginulus alte* Férussac, 1821
*Vaginula alte* Fischer, 1871.
*Vaginula maculosa* Hassett, 1830
*Vaginula frauenfeldi* Semper, 1885
*Vaginula leydigi* Simroth, 1889
*Veronicella willeyi* Collinge, 1900
*Vaginula leydigi celebensis* Simroth, 1918
*Vaginula leydigi keyana* Simroth, 1918
*Meisenheimeria alte* Grimpe & Hoffmann, 1925a

***Laevicaulis natalensis brauni***
*Vaginula* (*Annulicaulis*) *brauni* Simroth, 1913

***Laevicaulis stuhlmanni***
*Vaginula stuhlmanni* Simroth, 1895
*Laevicaulis stuhlmanni stuhlmanni* Forcart, 1953

## Common Name
**No common name, leatherleaf slugs**

***Laevicaulis alte:*** Tropical leatherleaf, lined leatherback slug

## Type of Pest
Mollusk

## Taxonomic Position
**Class**: Gastropoda, **Order**: Systellommatophora, **Family**: Veronicellidae

## Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List – 2011 through 2015*

*Originally listed under the family Veronicellidae.

## Pest Description
Veronicellidae are anatomically distinct from many other terrestrial slugs in that they have a posterior anus, eyes on contractile tentacles, and no pulmonate lung. The sensory tentacles are bilobed. This family also lacks a mantel cavity (Runham and Hunter, 1970).

Although this family is fairly easy to tell apart from others, species within this family can be difficult to distinguish due to similar morphology between species and multiple color variations within a single species. Taxonomy is based on the morphology of the hermaphroditic reproductive system.

***Laevicaulis alte***
Eggs: Eggs are oval and translucent, measuring 6 to 8 mm (approx. $^{1}/_{4}$ to $^{5}/_{16}$ in) in length (Herbert and Kilburn, 2004).

Adults: Most specimens are grayish in color with a thin, pale brown longitudinal line down the dorsal side (Herbert and Kilburn, 2004). Extended length can be up to 12 cm (4 $^{3}/_{4}$ in) (Herbert and Kilburn, 2004). *Laevicaulis alte* is very similar to *Laevicaulis natalensis* (Krauss) (Herbert and Kilburn, 2004). This species is well camouflaged and is commonly referred to as the “tropical leatherleaf”. “An inferior pair of tentacles on the head are bilobed and inconspicuous. The ventral side is broad, with a broad hyponotum on either side of a narrow (~5 mm wide [approx. $^{3}/_{16}$ in]) foot. The

respiratory orifice and anus are ventral, at the body posterior" (Brodie and Barker, 2012).

## Biology and Ecology

The biology of Veronicellidae is not well known; they are known to be nocturnal herbivores (Runham and Hunter, 1970).

### *Laevicaulis alte*

*Laevicaulis alte* is thought to be of African origin (Cowie, 2000). *Laevicaulis alte* has shown two distinct feeding peaks, both in the early and late hours of the night (Raut and Panigrahi, 1990).

Sexual maturity occurs when slugs reach about 4 cm (approx. 1 $^{9}/_{16}$ in) in length around seven months of age (Brodie and Barker, 2012). In Aurangabad, India, the breeding season was observed from June to September, with the greatest reproductive activity occurring right after the period of greatest rainfall. Egg laying occurred 15 to 20 days after mating with hatching occurring after about 17 days (Nagabhushanam and Kulkarni, 1970). Herbert and Kilburn (2004) state that *L. alte* eggs are deposited in a hole or depression in the soil a few days after mating; the eggs are joined together by an interconnecting thread forming a string that the parent shapes into a ball-like mass. The parent then deposits special fecal pellets on the top of the eggs that contain high concentrations of soil which help maintain high humidity levels. Eggs are laid in clutches of up to 100 (Herbert and Kilburn, 2004), with a general clutch size of 46 to 70 eggs. Temperatures between 15°C (59°F) and 35°C (95°F) are needed for egg hatch to occur. Mean development at 20°C (68°F) is about 20 days, and at 30°C (86°F) it is about 13 days (reviewed in South, 1992).

Hatching occurs around 1 to 3 weeks with newborn slugs measuring around 7 to 8 mm in length (approx. $^{5}/_{16}$ in). Maturity can be reached in as soon as five months, but breeding only occurs during favorable conditions. In India, *Laevicaulis alte* breeds during monsoon season, while South African populations breed in the warm, rainy summer months (Herbert and Kilburn, 2004). Populations increase during rainy seasons. This species can be found in leaf litter and under decaying wood, stones, grass, and ground crevices (Brodie and Barker, 2011). In Fiji, this species is found in lowland to high elevation forests, plantations, and moist, tall grasslands (reviewed in Brodie and Barker, 2012). This species is found in suburban gardens in the Darwin area of the Northern Territory, Australia (Smith and Dartnall, 1976).

Juveniles of this species usually search for food at night. During the day, they can stay buried in the soil during the day. Larger specimens can be active during cooler times of the day, but they also prefer night time activity (Brodie and Barker, 2012).

Individuals of this species are protandric hermaphrodites, meaning they are first male, and then develop female genitalia as they mature (Brodie and Barker, 2012). This species can also self-fertilize; successive generations have been maintained by self-fertilization (reviewed in South, 1992).

## Damage

Due to their apparent lack of host specificity, few reports as to specific damage caused by Veronicellidae species to agriculture have been published in the malacological or agricultural literature.

Visual signs of *Veronicellidae* can include chewing or rasping damage to plants, presence of eggs, juveniles and adults, mucus and slime trails, and/or ribbon like feces.

***Laevicaulis alte***

This species has been recorded eating tomatoes, spinach, and cucumbers (Brodie and Barker, 2012).

Kumari and Thakur (2006) looked at 'host' plant damage of 24 various 'host' plants in India and observed the most damage on: *Brassica oleracea* var. *capitata* (cabbage), *Brassica oleracea* var. *botrytis* (cauliflower), *Luffa acutangula* (anged luffa), *Luffa aegyptiaca* (Vietnamese luffa), *Catharanthus roseus* (Madagascar rosy periwinkle), *Colocasia esculenta* (taro), and *Cucumis sativus* (cucumber).

## Pest Importance

Veronicellidae can be pests in tropical regions of America, Africa, and Asia where distribution is limited (Runham and Hunter, 1970). This family can also transmit pathogens to humans indirectly when they consume vegetables and fruits that have been contaminated with mucus and feces. The slugs can also transmit pathogens to plants and livestock. Displacement of native mollusk species may also occur (USDA-APHIS, 2010a).

***Laevicaulis alte***

*Laevicaulis alte* is considered a serious agricultural pest in India where it is invasive (Herbert and Kilburn, 2004). Hosts include lettuce, spinach, and coriander (Raut and Panigrahi, 1990) as well as tobacco (Godan, 1983). *Laevicaulis alte* has been recorded as a pest of flower beds in India and has been found feeding on a number of ornamental plants including balsam, portulaca, marigold, verbena, dahlia, cosmos, narcissus and lily (Brar and Simwat, 1973); it has also been recorded as a pest in gardens where it can seriously damage seedlings and young plants of bean, cabbage, gourd, lettuce, and marigold (Raut, 1999). A more recent report states that this species has been found to damage oil palm seedings (Kalidas et al., 2006). This species has been recorded attacking *Nicotiana tabacum* (tobacco) in Oriental Africa, Pacific Islands, and Indonesia (reviewed in Godan, 1983).

Wen et al. (2007) states that *L. alte* is a pest of herbs in southern Taiwan, eating the leaves.

This species is considered a threat to vegetable and floriculture industries in Hawaii where it has been naturalized since at least 1927 (reviewed in USDA, 2013).
It is also an intermediate host to the larval stages of some nematode parasites of vertebrates (dog, cat, and rat lungworms) (Herbert and Kilburn, 2004). Brodie and

Barker (2012) state that this species has been reported by African farmers to be harmful to chickens if ingested.

## Known Food Sources*

These species are polyphagous, eating many different plants, organic material, and detritus (USDA-APHIS, 2010a). Lists are not meant to be all inclusive.

***Laevicaulis alte***

Plants fed upon include: *Abelmoschus esculentus* (okra), *Amaranthus tricolor* (=*A. gangeticus*) (Joseph's-coat), *Anethum graveolens* (dill), *Basella alba* (Malabar spinach), *Brassica nigra* (black mustard), *Brassica oleracea* (broccoli, cabbage, cauliflower), *Calendula officinalis* (cultivated marigold), *Catharanthus roseus* (Madagascar periwinkle), *Colocasia esculenta* (coco yam), *Coriandrum sativum* (coriander), *Cosmos bipinnatus* (cosmos), *Cucumis sativus* (cucumber), *Cucurbita pepo* (gourd), *Dahlia coccinea* (dahlia), *Elaeis guineensis* (African oil palm, seedlings), *Ipomoea alba* (tropical morning-glory), *Lablab purpureus* (hyacinthbean), *Lactuca sativa* (lettuce), *Lagenaria siceraria* (bottle gourd), *Lagenaria vulgaris* (bottle gourd), *Lilium philadelphicum* (wood lily), *Luffa acutangula* (towelsponge), *Luffa aegyptiaca* (sponge gourd), *Malus domestica* (apple, seedlings), *Myroxylon balsamum* (balsam), *Narcissus pseudonarcissus* (daffodil), *Nicotiana tabacum* (tobacco), *Phaseolus vulgaris* (bean), *Portulaca oleracea* (portulaca), *Solanum lycopersicum* (tomato), *Solanum melongena* (brinjal, eggplant); *Spinacia oleracea* (spinach), *Taraxacum officinale* (dandelion), and *Verbena polystachya* (verbena) (Raut and Panigrahi, 1990; reviewed in USDA, 2013).

*Terrestrial mollusks do not show host specificity and can feed on multiple crops as well as other materials, like decaying organic matter.

## Pathogen or Associated Organisms Vectored

**Human and Animal Pathogens**

Species of this family have been found to carry several nematode parasites, including *Angiostrongylus cantonensis* (rat lungworm), *A. costaricensis*, and *A. malaysiensis*. *Angiostrongylus cantonensis* can cause symptoms similar to meningitis in humans including headache, stiff neck, tingling or painful feelings in the skin, low grade fever, nausea, and vomiting (USDA-APHIS, 2010a).

*Laevicaulis alte* has been experimentally infected with *Anafilaroides rostratus*, a parasite of the bronchii of cats (Malek, 1980). It can also carry *Angiostrongylus cantonensis* (rat lungworm) (Godan, 1983). *Angiostrongylus cantonensis* has been found in naturally occurring populations of *L. alte* on Pacific islands and Japan (reviewed in South, 1992).

Note: While most cases of human infections result from consumption of raw or partially cooked snail meat, government inspectors, officers and field surveyors are at-risk due to the handling of live snail, samples, and potential exposure to mucus secretions. ***Wear gloves when handling mollusks and wash hands thoroughly after any mollusk survey or inspection activities.***

**Plant Pathogens**
Unknown.

## Known Distribution

This family is widely distributed in tropical regions of South America, southern Asia, Africa, Madagascar, and Indian Ocean Islands (Herbert and Kilburn, 2004). Distribution lists may not be all inclusive.

***Laevicaulis alte***
*Laevicaulis alte* is native to Central and East Africa southwards to KwaZulu-Natal (Herbert, 2010). This species has been introduced and established in many tropical areas (Herbert and Kilburn, 2004). It is established in Cameron County, Texas. (Robinson, 2014, personal communication)

**Africa:** Democratic Republic of Congo (formerly Zaire), Malawi, South Africa, and Tanzania; **Asia:** Andaman and Nicobar Islands, China, India, Indonesia, Japan, Malaysia, Philippines, Sri Lanka, Taiwan, and Thailand; **Oceania:** Australia, , Fiji, French Polynesia, Hawaii, Midway Islands, New Caledonia, New Guinea, Torres Islands, Vanuatu, Samoa and American Samoa (Gomes and Thomé, 2004; reviewed in USDA, 2013).

***Laevicaulis natalensis brauni***
**Africa:** South Africa (Thomé et al., 1997).

***Laevicaulis stuhlmanni***
**Africa:** Democratic Republic of Congo (formerly Zaire) (Thomé et al., 1997).

## Pathway

Unidentified slug species have been previously intercepted at U.S. ports of entry on several types of material, including ornamentals, nursery stock, and cut flowers (reviewed in USDA, 2013).

This genus can move through international trade. From 1985 to 2009, *Laevicaulis alte* has been intercepted a total of 4 times on 4 different plant genera (USDA-APHIS, 2010a). Spread of *L. alte* has most likely occurred through human activities, including ornamental and horticultural trade (USDA-APHIS, 2010a). USDA (2012) states that this species may move through unmitigated growing media of *Oncidium* plants from Taiwan.

The find in Harlingen, Texas was associated with freshly laid sod and a flower bed suggesting that the species may have been moved to the location via the sod pathway. In general, slugs have been found to be moved on potted plants (reviewed in USDA, 2013).

## Potential Distribution within the United States

Host material is unlikely to limit distribution of tropical terrestrial mollusks since they are polyphagous, but these species are limited by climate. If introduced, the tropical

terrestrial mollusks would most likely be limited to the southern part of the United States and possibly the West Coast where the climate is similar to native ranges. This is supported by detections of these species which have all been in either the southern United States or West Coast (USDA-APHIS, 2010a).

***Laevicaulis alte***

A risk map developed by USDA using the known distribution of *L. alte* and plant hardiness zone matching predicts that this species is likely to occur in plant hardiness zones 9 through 13.

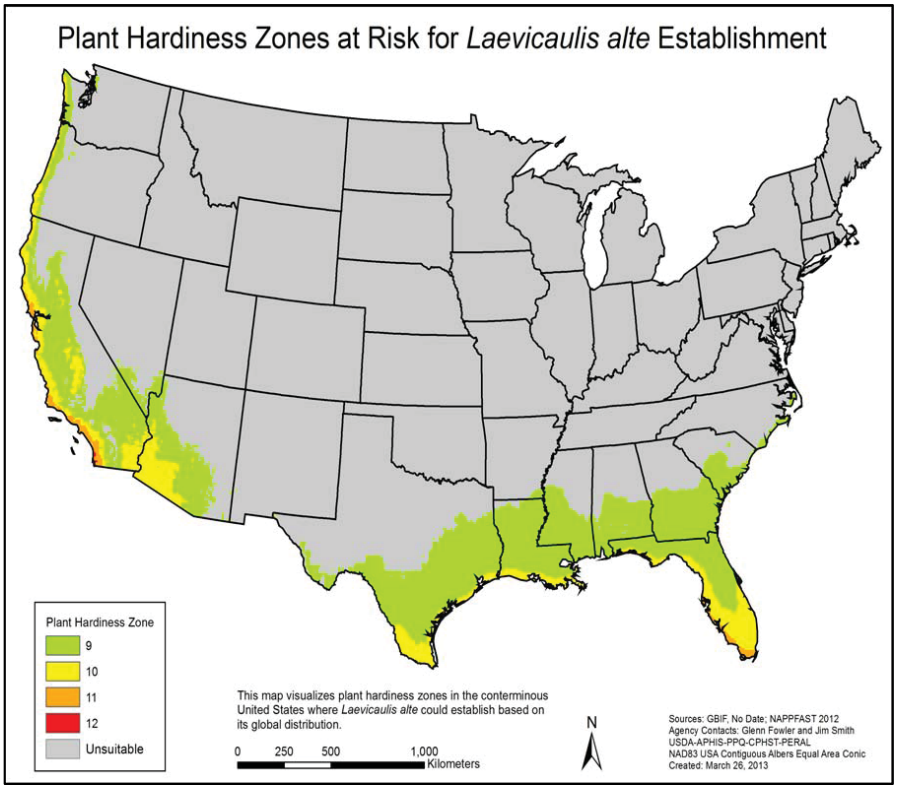


**Figure 3.** Potential projected distribution of *Laevicaulis alte* in the United States based on plant hardiness zone climate match with Figure 2 (G. Fowler, USDA-APHIS-PPQ-CPHST-PERAL).

Although this species is found in tropical areas, this species also has several adaptations for living in dry conditions, including a leathery dorsum (surface) and a narrow foot to reduce evaporation (Brodie and Barker, 2012). Because of this, it may be likely to establish outside of the projected risk areas.

This species has been established in Hawaii since 1900 (Bishop Museum, 1999). It is considered naturalized there and is subject to pre-clearance PPQ activities due to its known status as a hitchhiker pest (reviewed in USDA, 2013). Cowie (1998) states that this species was likely accidentally introduced into Hawaii. It is interesting to note that this species became widespread and abundant in Hawaii after its introduction, but now is relatively rarely seen. "Anecdotal observations suggest that its decline has coincided

with the introduction in the 1970s of another veronicellid, *Vaginula* [*Sarasinula*] *plebeia*, which is now far more common" (Cowie, 1998).

It was also reported from Texas but may have died out (D. Robinson, personal comm., 2010). In 2013, specimens of *L. alte* were found in Harlingen, Texas. This detection was classified as a regulatory incident and is not considered established in Harlingen (USDA, 2013).

## Survey

**CAPS-Approved Method*:**

Visual. See the Introduction to the mollusk manual for specific information on visual surveys.

Survey Site Selection

New introductions of terrestrial mollusks will likely be related to commerce and human-assisted movement. The habitat and land-use type of each survey site may be variable, ranging from agricultural land, to residential or industrial features. When planning the survey route for a particular site, examine the following microhabitats:

- Near heavily vegetated areas, especially gardens and fields where plants have been damaged by feeding;
- Under rocks, asphalt or cement pieces that are in loose contact with the ground surface;
- Discarded wooden boards and planks, fallen trees, logs, and branches;
- Damp leaf litter (not wet or soggy), compost piles, and rubbish heaps; and
- Under flower pots, planters, rubber mats, tires and other items in contact with the soil.

Trap Placement

Trapping ***cannot*** be used alone, but can be used to supplement visual surveying. Trapping for terrestrial mollusks is not species specific and will attract non-target species, including non-mollusks. Platform or baiting traps can be used to supplement visual inspection. Trap placement can occur in the same areas that visual surveys occur.

Time of year to survey

Most species of terrestrial mollusks are active during nocturnal hours, when environmental conditions are cool and wet. Some species may also be active during daylight, especially during overcast and rainy days in the spring and fall. If possible, plan surveys during spring and fall, and during early morning and overcast days. Many slugs and snails have diurnal patterns of activity, so early morning and evening hours may be the best time to carry out a survey (Pearce and Örstan, 2006).

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

## Key Diagnostics/Identification

**CAPS-Approved Method*:**

Morphological and Molecular: Differentiation from the native species is only by dissection and only if the specimen is mature enough. All veronicellid samples should be sent to Dr. Robinson for morphological identification. All specimens will then be confirmed through molecular diagnostics performed at the CPHST Mission lab.

A key to terrestrial mollusks (including Veronicellidae) is found here: http://idtools.org/id/mollusc/index.php.

In April 2013, the family Veronicellidae, a target on the 2013 and 2014 AHP Prioritized Pest Lists, was broken down into six genera of concern. When conducting a general mollusk survey, if samples are negative for Veronicellidae, then negative data may be reported for each of these six genera: *Belocaulus, Colosius, Laevicaulis, Sarasinula, Semperula,* and *Veronicella*. All positives must be reported at the species level.

Refer to "Appendix N - Data Entry Guide for Selected Taxonomic Groups" of the most recent year's CAPS Guidelines for additional information on data entry for mollusks https://caps.ceris.purdue.edu/caps_agreement_guidelines.

*For the most up-to-date methods for survey and identification, see Approved Methods on the CAPS Resource and Collaboration Site, at http://caps.ceris.purdue.edu/.

## Easily Confused Species

*Laevicaulis alte* can be confused with one native species, *Leidyula floridana.* It may also be confused with exotic species that are either not known to be established or of limited distribution in the United States.

*Laevicaulis alte* is very similar to *Sarasinula plebeia*; the latter has a narrower body shape and is brown. It is also similar to *Parmarion martensi* which has a similar thin pale stripe to the mid-posterior of the mantle. However, *P. martensi* has a visceral hump and a small plate-like shell on the back (Brodie and Barker, 2012).

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