

= Camas pocket gopher =

The camas pocket gopher (*Thomomys bulbivorus*), also known as the camas rat or Willamette Valley gopher , is a rodent , the largest member in the genus *Thomomys* , of the family Geomyidae . First described in 1829 , it is endemic to the Willamette Valley of northwestern Oregon in the United States . The herbivorous gopher forages for vegetable and plant matter , which it collects in large , fur lined , external cheek pouches . Surplus food is hoarded in an extensive system of underground tunnels . The dull brown to lead gray coat changes color and texture over the year . The mammal 's characteristically large , protuberant incisors are well adapted for use in tunnel construction , particularly in the hard clay soils of the Willamette Valley . The gophers make chattering sounds with their teeth ; males and females make purring (or crooning) sounds when they are together , and the young make twittering sounds . Born toothless , blind and hairless , the young grow rapidly before being weaned at about six weeks of age .

Although the camas pocket gopher is fiercely defensive when cornered , it may become tame in captivity . While population trends are generally stable , threats to the species ' survival include urbanization , habitat conversion for agricultural use and active attempts at eradication with trapping and poisons . It is prey for raptors and carnivorous mammals , and host to several parasitic arthropods and worms . Scientists believe that the gopher 's evolutionary history was disrupted when the Missoula Floods washed over the Willamette Valley at the end of the last ice age . The floods almost completely inundated its geographic range , which may have caused a genetic bottleneck as survivors repopulated the region after the waters receded .

= = Taxonomy = =

There are six genera of North American pocket gophers : *Cratogeomys* , *Geomys* , *Orthogeomys* , *Pappogeomys* , *Thomomys* , and *Zygogeomys* . The camas pocket gopher is a smooth toothed pocket gopher of the genus *Thomomys* , within the pocket gopher family Geomyidae . The incisors of gophers in the genus *Thomomys* have characteristically smooth anterior surfaces , while those of *Geomys* have two deep grooves per tooth and those of *Cratogeomys* have a single groove . The camas pocket gopher is a member of the subgenus *Megascapheus* , established in 1903 , at that time for the camas pocket gopher alone . Taxonomists subsequently assigned other gophers to the same subgenus . The name *Thomomys* derives from the Greek *thomē* (heap) + *mys* (mouse) , probably describing the mounds of excavated soil produced by the burrowing gopher . *Bulbus* translates as " bulb " in Latin , and the word for " devour " is *voro* . Naturalist David Douglas reported that the gopher consumed bulbs of the camas lily , and Vernon Bailey later attributed the lack of camas lilies in areas inhabited by the gopher to the bulbs being eaten . However , naturalist H. M. Wight observed that the gopher ate primarily dandelion greens , and was skeptical that it was a large consumer of bulbs .

= = Early history = =

The taxonomy of the camas pocket gopher and its genus , *Thomomys* , have a convoluted history . According to a review article published by the American Society of Mammalogists in 1987 , Johann Friedrich von Brandt was the first to refer to the camas pocket gopher as *Thomomys bulbivorus* in an 1855 article published by the Imperial Academy of Sciences . In the 1855 article , Brandt refers to *Tomomys bulbivora* without the " h " and ending with an " a " . He writes parenthetically " (man schreibe nicht *Thomomys*) " . The authors of the 1987 review note that they did not see Brandt 's actual article , but source the textbook *The mammals of North America* published in 1981 .

Early confusion arose from writings by John Richardson between 1828 and 1839 . Although he describes six species in the genus , according to later critics he was unfamiliar with all specimens . Richardson 's descriptions of the animals and the figures in the text were also criticized . His 1829 *Fauna boreali americana* describes a type specimen of camas pocket gopher obtained from the " banks of the Columbia River , Oregon " , the northern limit of the gopher 's geographic range .

This was probably Portland , at the confluence of the Willamette and Columbia Rivers , the only place on the Columbia where subsequent specimens have been found . The present location of this initial specimen is uncertain ; reportedly stored at the Hudson Bay Museum , it could not be located in 1915 . When Richardson made his first examination , the specimen was apparently incomplete ; although Joel Asaph Allen wrote in 1893 that it consisted only of the skin , Richardson described the skull and facial features in detail .

In *Fauna boreali-americana* , Richardson assigns the mammal to the now defunct genus *Diplostoma* described by Rafinesque in 1817 . He named it *Diplostoma ? bulbivorum* . Illustration labeling errors in Richardson 's book further confounded subsequent taxonomists ; the plate was labeled *Diplostoma douglasii* .

There is a specimen of a quadruped in the Hudson 's Bay Museum , which Mr David Douglas informs me is the animal known on the banks of the Columbia by the name of the camas rat , because the bulbous root of the Quamash or Camas plant (*Scilla esculenta*) forms its favourite food . The skull is wanting , and the animal , therefore , cannot be with certainty referred to a genus , but the form of its exterior cheek pouches leads me to think that it may belong to the *diplostoma* of M Rafinesque Schmaltz .

The confusion around the species ' taxonomy and identification amplified when naturalist Spencer Fullerton Baird interpreted Richardson 's reports . The camas pocket gopher 's large size led Baird to conclude that the animal 's measurements (reported by Richardson) were an artifact of its taxidermy preparation . Baird was also apparently in error about the location from which the specimen was taken , attributing the name *Thomomys bulbivorus* to a set of previously collected specimens later known as the California Gopher . This confusion was echoed by subsequent authors . The article on gophers in the 1879 edition of the *American Cyclopædia* has an illustration captioned " California Gopher (*Thomomys bulbivorus*) " . The ninth edition of the *Encyclopædia Britannica* (published during the late 19th century) mistakenly reports *Thomomys bulbivorus* as abundant along the central California coast .

== Clarifications ==

Although Baird and Elliott Coues were involved in early assessments of the genus , according to Allen neither ever saw a specimen of the camas pocket gopher (*T. bulbivorus*) . Allen obtained and examined two large adults (male and female) collected in Beaverton , Oregon in May 1890 which were considerably larger and darker than previously examined specimens . Skull features and white markings around the mouth and anus also differed . His findings and the specimen collection location helped identify the camas pocket gopher as a species separate from California gophers . The California specimens were classified by Eydoux and Gervais as *Oryctomys bottae* , now known as *Thomomys bottae* (Botta 's pocket gopher) . They were found near Monterey , California , over 1000 kilometers (620 mi) south of the now recognized range of the Camas pocket gopher .

The distribution of Elliot 's " great pocket gopher " (as it was known) extended along the California coast " north of San Francisco . " James Audubon and John Bachman reassessed the taxonomy on the camas pocket gopher in the late 1800s . They referred it as the " camas rat " . They reclassified the gopher as *Pseudostoma borealis* . They rejected *Diplostoma* as a genus , and assigned *Diplostoma bulbivorum* as synonymous with *P. borealis* . They attributed any differences described by Richardson to artifact , from a specimen that was " twisted and disfigured " in preparation . Based on observations of taxidermy specimens in Europe , they suggested that Townsend 's pocket gopher (*Geomys (Thomomys) townsendii*) belonged to the same species . In 1875 the camas pocket gopher was reported as a subspecies of the northern pocket gopher (*Thomomys talpoides*) , . During the 1920s H. M. Wight referred to it colloquially as the " Willamette Valley gopher " .

== Current phylogeny ==

In 2008 , a team of biologists from University of California , Berkeley and Harvard University published multilocus phylogenetic analysis results of the genus *Thomomys* . The camas pocket gopher was found to be well separated from other taxa in the subgenus *Megascapheus* . These findings suggested that the camas pocket gopher was a sister to the other taxa in the subgenus , but the relationships between those other animals was less clear . Only one camas pocket gopher was included in this study , which limited the ability to distinguish features such as monophyly . The following cladogram was presented showing the placement of the camas pocket gopher among its closest relatives :

Patterns of genetic variation in the camas pocket gopher have been studied . Although there are no subspecies , there is substantial genetic diversity within the species . Its genetic patterns are consistent with limited inbreeding within specific populations . This is similar to patterns described in Botta 's pocket gopher and the southern pocket gopher , both of which are members of the same genus . However , it contrasts with patterns noted in Baird 's pocket gopher and the plains pocket gopher , members of a separate genus , *Geomys* , which showed a higher degree of inbreeding .

The species ' genetic diversity is similar to that of other pocket gophers occupying a larger geographic range and diversity of habitat . Compared to Townsend 's pocket gopher , which is distributed across a much larger area , but less diverse habitat , it is more genetically heterogeneous . Although there is considerable differentiation between separate populations of camas pocket gophers , their genetic variability does not affect the mammal 's appearance . Study of the effects of genetic change over time revealed a pattern affected by a cataclysmic event across the species ' entire geographic area about 13 @, @ 000 years ago . Such an event would cause a population bottleneck , leading to scattered , isolated populations .

= = Description = =

The camas pocket gopher is , by a small margin , the largest member of its genus (*Thomomys*) . The fur is a dull brown above and dark , leaden gray beneath . There are often patches of white on the chin , throat and around the anus , and it has blackish ear and nose markings . The external ear is a thickened rim of tissue . During the summer , the gopher 's coat is short and coarse ; winter pelage is longer and furrier . The coat of the young is similar to the adult summer coat , but with more sparsely distributed fur ; the abdominal skin may be visible .

Like other gophers , it has small eyes and ears and a nearly hairless tail . Its shoulders are broader than its hips . It is pentadactyl , with five claws on each foot . The claws on its forefeet are longer than those on its hind feet , and its middle claws are longest . The front claws of the camas pocket gopher are short and weak relative to its size . It employs plantigrade locomotion . The male is larger than the female , measuring an average 300 mm (12 in) in length . A large male weighs about 500 g (18 oz) . One male specimen was 321 mm (12 @. @ 6 in) long and weighed 633 @. @ 8 g (22 @. @ 36 oz) . Females are about 271 mm (10 @. @ 7 in) long . The tail measures 90 mm (3 @. @ 5 in) in the male and 81 mm (3 @. @ 2 in) in the female . An adult male 's hind feet measure 40 ? 43 mm (1 @. @ 6 ? 1 @. @ 7 in) , and an average female 's hind feet measure 39 mm (1 @. @ 5 in) . There are four mammary glands : two in the inguinal region and two in the pectoral region , each supplying a pair of nipples . Morphologically , it most closely resembles Botta 's pocket gopher ; differentiation can be made based on the concavity of the inner surface of the pterygoids , small claws , more uniform fur coloring and exoccipital groove of the camas pocket gopher .

= = Skull and dentition = =

The skull of the camas pocket gopher is sturdily proportioned . The camas pocket gopher and other smooth @-@ toothed pocket gophers with robust snouts are included in the subgenus *Megascapheus* . Male skulls measure 52 mm (2 @. @ 0 in) in length across the base and 57 mm (2 @. @ 2 in) if the incisors are included . The short , wide skull has a relatively short nasal passage . In width , the skull measures 19 mm (0 @. @ 75 in) across the nasal passages , 30 @. @ 5 mm (1 @. @ 20 in) across the mastoids and 36 @. @ 5 mm (1 @. @ 44 in) at the zygomatic arches .

The external auditory meatus is broad and open , although the auditory bullae are confined .

The dentition of the camas pocket gopher is symmetric , with one set of incisors , one set of premolars , and three sets of molars above and below . This gives a dental formula of $1 \frac{1}{1} \frac{0}{0} \frac{3}{3}$, for a total of 20 teeth . The slender incisors are prominent and distinctive , smooth with yellow surface enamel and white tips due to soil abrasion . These distinctive , large , protuberant upper incisors give the gopher a buck-toothed appearance . The lips do not cover the incisors , but close behind them . There are faintly visible grooves on the inner aspect of the upper incisors , which are more pronounced in other members of the genus (such as the Mazama pocket gopher , *T. mazama*) . The upper molars have an alveolar length of 10 mm (0.39 in) .

== Cheek pouches ==

Gophers are burrowing rodents of the family Geomyidae , characterized by fur-lined , external cheek pouches used to gather and transport food . The cheek pouches of geomyids such as the camas pocket gopher are controlled by a set of muscles , with a sphincter controlling the opening and closing of the pouch . A pair of muscles attached to the premaxilla pull the pouches forward , and paired retractor muscles pull the pouches back . These retractor muscles extend back and up from the cheek surfaces , forming a band 7 ? 10 cm (2.8 ? 3.9 in) long and about 2 cm (0.79 in) wide attached to aponeurosis of the latissimus dorsi muscle .

== Male genitalia ==

Like many mammals the penis of the camas pocket gopher contains a bone , the baculum . Although its baculum was initially reported as smaller than that of other gophers ? 1 @. 5 mm (0 @. 059 in) high , 1 @. 8 mm (0 @. 071 in) wide at the base and 8 @. 5 mm (0 @. 33 in) long ? the examiner did not know if the specimen had reached full maturity . Subsequent reports averaged about 2 @. 1 mm (0 @. 083 in) high , 2 @. 2 mm (0 @. 087 in) wide at the base and 10 @. 1 mm (0 @. 40 in) long . The phallus ' total length averaged 13 @. 5 mm (0 @. 53 in) , with the glans covering more than half its length .

== Distribution and habitat ==

The camas pocket gopher is found in the Willamette Valley and the drainage areas of the Yamhill River and other tributaries of the Willamette River . Its range extends north from Eugene to Portland and Forest Grove and west to Grand Ronde . A 1920 report of a Pleistocene fossil in Fort Rock , Oregon has been questioned , since it is far outside the species ' current geographic range ; as of 1987 , the specimen could not be located for further evaluation .

The clay-rich Willamette Valley soils are hard in the dry season , and the gopher 's protuberant incisors are well adapted to these conditions . Adequate soil drainage and suitable plant food are essential components of the gopher 's ideal habitat . Not typically found in wetland areas (where its tunnels would flood) , the species is found in seral communities of grasses and shrubs . They are also established in agricultural fields in the Willamette Valley , including fields of alfalfa , wheat and oats . The species has also been found in areas of ecological disturbance with similar terrain features .

On a geologic timescale , the Willamette Valley has been the site of massive floods . During the late Wisconsin glaciation , a series of floods (known as the Missoula or Bretz Floods) occurred . The last flood in the series , a massive flood with an estimated 1 @, 693 km³ (406 cu mi) of water flowing at a rate of 42 km³ per hour (412 million ft³ per second) over a 40 @-hour period , occurred about 13 @, 000 years ago . The flood filled the Willamette Valley to a depth of about 122 m (400 ft) , in a near @-perfect overlay of the camas pocket gopher 's range . Although the species has been collected above this elevation , such finds are uncommon . A temporary lake , Lake Allison , formed . Although it is assumed that the gopher lived in the valley before the flood , no

fossils have been recovered . The Chehalem Mountains , with a peak elevation of 497 m (1 @, @ 631 ft) , probably provided refuge for survivor populations and survivors would have repopulated in isolated pockets when the waters receded . Before and since the floods , the mountains are thought to have limited gene flow between populations . The relatively narrow , sluggish Willamette River does not appear to obstruct genetic flow in gopher populations .

= = Behavior = =

The gopher has been credited with being one of the most vicious animals known for its size . It has a great deal of courage and fights a man savagely until an opportunity for escape is offered , then it turns and runs as rapidly as possible , attempting to hide from its pursuer .

The camas pocket gopher is a mostly solitary herbivore which is active throughout the year and does not hibernate . The gopher spends most of its time excavating tunnels in search of food , and the hard clay soils of the Willamette Valley pose a challenge . Although the gopher 's front claws are too weak to dig through the clay (particularly during dry seasons) , its large incisors and strongly protuberant orientation are well @-@ adapted for this purpose . Tunnel systems constructed by the camas pocket gopher can be complex , with some tunnels exceeding 240 m (260 yd) in length . About 90 mm (3 @. @ 5 in) in diameter , the tunnels are up to 0 @. @ 91 m (3 @. @ 0 ft) deep . When soils are damp the gopher constructs ventilation ducts or chimney mounds (possibly unique to the species) , to increase ventilation . The chimney mounds rise vertically 15 ? 25 cm (6 ? 10 in) , are open at the top and are thought to ventilate the burrows in accordance with Bernoulli 's principle . It is not known if adjacent gopher burrowing systems interconnect . Reports differ about whether or not the ranges of the camas pocket gopher and the Mazama pocket gopher overlap ; if so , this refutes the previous belief that Oregon gopher ranges do not overlap .

Although the species is primarily fossorial , it occasionally gathers food near the entrance of a tunnel . Dandelions seem to be its favorite food , and are also used as nesting material . During breeding season males will enter the tunnels of females , and males and females may make purring (or cooing) sounds when they are together . Mothers seem to comfort the young by softly vocalizing , with the young twittering in response .

The camas pocket gopher may behave aggressively when on the defensive , with mammalogist Vernon Orlando Bailey describing the species as " morose and savage . " However , it may be easily tamed in captivity ; the female is more readily tamed than the male . Another small rodent endemic to the Willamette Valley , the gray @-@ tailed vole (*Microtus canicaudus*) , also uses camas pocket gopher tunnels . Other mammals sharing the range of the camas pocket gopher (and , possibly , its tunnels) include the vagrant shrew , Townsend 's mole , the brush rabbit , the eastern cottontail rabbit , Townsend 's chipmunk , the California ground squirrel , the dusky @-@ footed woodrat , the North American deer mouse , the creeping vole , Townsend 's vole , the Pacific jumping mouse , the long @-@ tailed weasel and the striped skunk .

= = Ecology = =

Varying onset times and duration of the camas pocket gopher breeding season have been reported . Early reports suggested an early @-@ April onset , with the season extending through June . Other reports cited " evidently pregnant " females seen in late March . In heavily irrigated areas the breeding season may be longer , extending into early September . About four young are born in a litter , although litters as large as nine have been reported . The blind , hairless , toothless offspring weigh about 6 @. @ 1 g (0 @. @ 22 oz) and are 50 mm (2 @. @ 0 in) in length . During their first six weeks they will begin to crawl , develop cheek pouches , open their eyes and wean from milk to solid food . The young then weigh about 86 g (3 @. @ 0 oz) and measure 164 mm (6 @. @ 5 in) in length . At weeks 8 , 10 and 17 they will weigh 101 g (3 @. @ 6 oz) , 160 g (5 @. @ 6 oz) and 167 g (5 @. @ 9 oz) . Some reports indicate that more than one litter may be born in a season . Sexual maturity probably develops by the following year 's breeding season . Although males are fully grown by that time , females may continue to increase in size .

There is little data on the longevity and mortality of the camas pocket gopher . It is presumably prey for carnivorous mammals , and its bones have been identified in regurgitated pellets of raptors such as the great horned owl . Parasites include mites , lice , fleas , roundworms and flatworms . The species ' tougher skin may protect it from some fleas known to infest Botta 's pocket gopher and the Mazama pocket gopher . Mites known to parasitize the camas pocket gopher include *Androlaelaps geomys* and *Echinonyssus femoralis* . Some authorities report *Androlaelaps fahrenheiti* as another parasitic mite , but a later publication did not report it . The chewing louse *Geomydoecus oregonus* has also been reported .

Two parasitic worms first discovered in the gastrointestinal tract of camas pocket gophers are the nematode *Heligmosomoides thomomyos* and the cestode *Hymenolepis tualatinensis* . Other worms include two nematodes and the cestode *Hymenolepis horrida* .

= = Human interactions = =

Camas pocket gophers cause significant economic losses , so may be treated as an agricultural pest . Crops damaged include clover , alfalfa and vetch . The gophers may eat these crops or damage the roots while burrowing . This can injure the roots and expose them to air , causing them to dry out . Subterranean activity can also damage the roots of fruit trees . Root crops are particularly susceptible to damage and consumption ; potatoes , carrots , parsnips and other crops may be eaten on site or dragged off by the gopher for caching in the burrow . Excavated soil can cover grass and limit livestock grazing ; freshly sprouted grains may be similarly damaged . An estimate of impact from camas pocket gopher activities in the Willamette Valley in 1918 amounted to \$ 1 @. @ 5 million annual losses . Gopher activities can provide a benefit of soil aeration , enhancing water retention after rain or snowmelt . Buried vegetation can also compost , enhancing organic soil content to provide additional benefits .

Proposed methods for controlling gopher populations in agricultural areas include poisoning dandelions , clover , carrots , sweet potatoes and parsnips . Camas pocket gophers are larger than other gophers , so conventional gopher traps may fail to capture them . Toxic baits and fumigants may also fail , since the gophers will sometimes wall off a segment of the burrow . Gophers may also cause local flooding if their tunneling activities damage levees .

In an effort to mitigate damage by camas pocket gophers to sensitive habitat , the Oregon Department of Transportation and the Institute for Applied Ecology trap and relocate the animals . At a site south of Philomath , Oregon , the IAE is working to protect a small but viable population of Kincaid 's lupine (*Lupinus sulphureus*) . This threatened flower is the primary host plant for the endangered Fender 's blue butterfly (*Icaricia icarioides fenderi*) , which is endemic to the Willamette Valley . The gophers are relocated to a nearby location distant from the lupines .

= = = Conservation status = = =

Citing concerns of urbanization , habitat loss and active attempts at eradication , NatureServe assesses the camas pocket gophers ' conservation status as vulnerable . The conservation status of the camas pocket gopher is classified as " least concern " by the IUCN (International Union for Conservation of Nature) Species Programme , with a stable population trend . The IUCN notes that the gopher is common in its range ; studies indicate that populations can recover rapidly after traps are removed from an area , and the species may adapt well to environmental changes .

The IUCN and others express concern about degradation of the species ' habitat due to urbanization and agricultural expansion . The total area occupied by the camas pocket gopher is less than 20 @, @ 000 km² (7 @, @ 700 sq mi) . This area , the Willamette Valley contains 70 percent of Oregon 's human population . Although this range probably contains a few protected areas , many preserves in the valley are primarily waterfowl protection for hunters . Wetland areas are not suited to the camas pocket gopher , since tunnels are flood @-@ prone . In areas better suited to the gopher (disturbed habitats and pastoral farmland) , it may be considered a pest and subject to eradication by poisoning and trapping .

