

Chewcard keys and species descriptions (v1.3)

Notes and definitions for using the keys

- The key presents a series of numbered (at left margin) paired statements (23 pairs). Starting at statement-pair 1, choose the statement within the pair that most closely matches the chewcard being examined, then proceed to the statement pair indicated by the number to the right of the chosen statement. Eventually a species will be “keyed out” when a selected statement is followed by a species name instead of a number. That species description (description can be found below the key) can then be read to confirm (or otherwise) the keyed-out result.
- Presented chewcards are folded in half, and therefore have a top and bottom half. Each half has two surfaces, referred to as the upper and lower surfaces.
- Where not specified, measurements are for upper-jaw teeth – the impressions are further into the card than for lower-jaw (mandible) teeth.
- Incisors are broad/flat chisel-shaped teeth at the front of the jaw. Canines are pointed, round in cross-section, and located near the front of the jaw (immediately adjacent to any incisor teeth).
- Incisors are measured in pairs (Figure 1), while canines are measured as inter-canine distances (centre to centre; Figure 1) using the smallest-diameter holes to minimise distortion/tearing.
- Medial notches/gaps are indentations or gaps between incisor teeth impressions.
- Measurements are recorded to the nearest 0.5 mm.
- “±” means “with or without”.

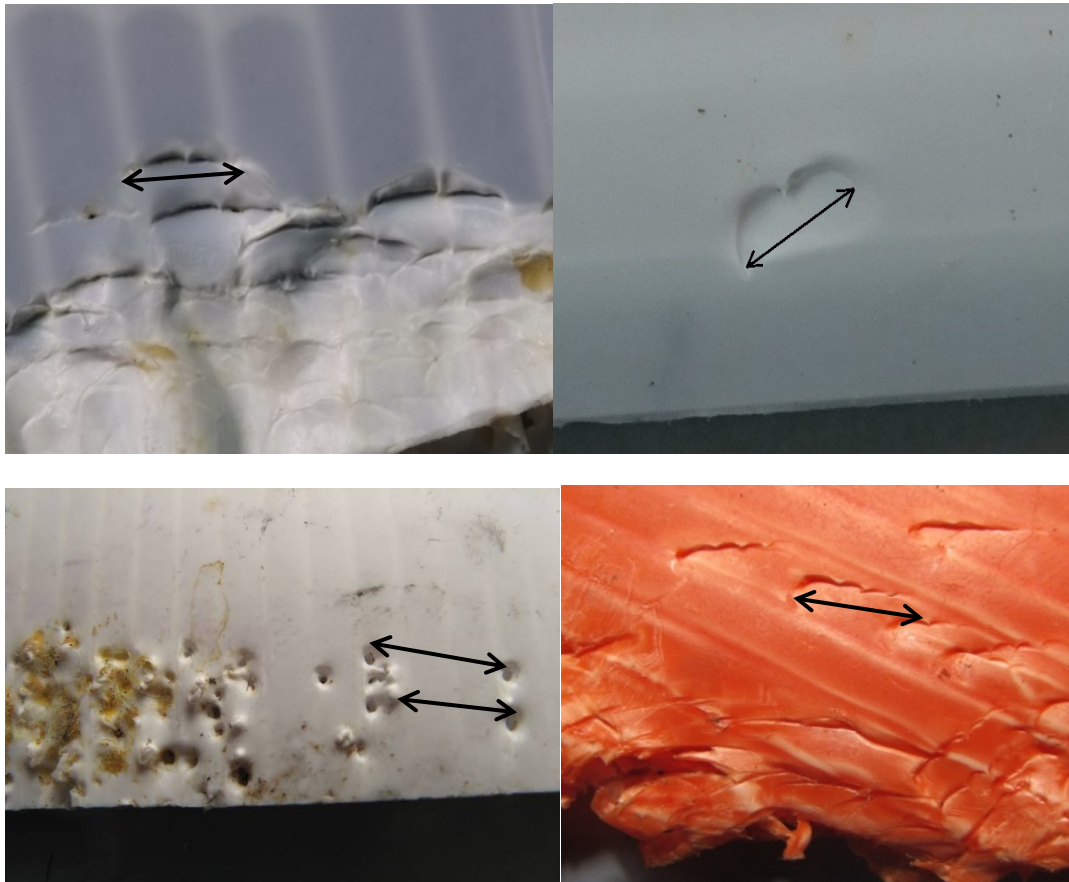


Figure 1. Examples of bite-mark measurement. The top row shows possum (left) and rat (right) incisor-pair impressions. The lower left shows inter-canine distances for the upper and lower jaw of a stoat. The lower-jaw (mandible) canine impressions of the stoat are small bumps made by the teeth pushing the card from below. The lower right shows the four 'humps' that are a distinguishing feature of the upper incisor-pair of lagomorphs (rabbits and hares).

Chewcard bite mark key: Version 1.3 (30/6/2018)

1	– Card material crushed and/or with tooth impressions, but not cut, torn or punctured.....	2
	– Card material missing, cut, torn or punctured.....	12
2	– Crushing and/or tooth impressions on both card surfaces or only within 5 mm of the card margin on one surface only	3
	– Blunt impressions of up to 8 incisor teeth in an arc on one surface only	9
3	– Card material crushed and/or incisor impressions on both surfaces, or only within 5 mm of the card margin on one surface only	4
	– Card material crushed and/or blunt incisor tooth impressions on one surface only, with pointed impressions on the opposite surface	7
4	– Distinct incisor-pair impressions <30 mm in from the card margin on one or both surfaces	5
	– Blunt, variable tooth impressions covering much or all the card face on both surfaces	ungulate
5	– Incisor-pair impressions >3 mm wide, ± card margins extensively crushed	6
	– Incisor-pair impressions <3 mm wide, ± crushed margins < 10 mm in from the card margin or cut edge	8
6	– Curved incisor-pair impressions 4–7 mm wide, with one medial notch or gap ranging from a small V to a gap of up to 1 mm wide, within and/or beyond any crushed areas	possum
	– Straight upper incisor-pair impressions 5–6.5 mm wide, comprising 4 distinct humps, ± straight lower incisor pairs 5.5–7.0 mm wide with 1 medial notch only	rabbit/hare
7	– Crushed drag marks ± well defined upside-down U-shaped impressions, 6 mm wide, without a medial notch; opposite surface with V-shaped impressions, 2–3 mm wide, pointing away from the margin	kea
	– Blunt incisor-pair impressions, 3–4.5 mm wide, ± crushing on one surface; opposite side with small, oval, canine impressions with inter-canine distances 3.0–6 mm	hedgehog
8	– Incisor-pair impressions 1.6–2.6 mm wide, isolated and/or numerous within crushed zone	rat
	– Incisor-pair impressions 0.8–1.4 mm wide, isolated and/or numerous within crushed zone	mouse
9	– Impressions of 4–8 incisor teeth forming arcs 20–80 mm wide ± indistinct shallow ridge or depression on the opposite surface.....	ruminant
	– Incisor-pair or single-tooth impressions < 5 mm in from the card margin.....	10
10	– Incisor-pair impressions >3 mm wide, or individual incisor teeth impressions >1.5 mm wide	6

	– Incisor-pair impressions <3 mm wide or individual incisor teeth impressions <1.5 mm wide	11
11	– Incisor-pair impressions 0.8–2.6 mm wide.....	14
	– Small, circular or pointed impressions <0.3 mm diameter invertebrate	
12	– Card material missing along margins and/or fold line, on one or both surfaces of the card.....	13
	– One or both card surfaces punctured, cut or torn, but no material missing except ± corners torn due to heavy biting.....	16
13	– Card margins removed, cut by sharp teeth; ± numerous incisor pair impressions, close and parallel to the cut edge. Straight upper incisor-pair impressions 5–6.5 mm wide, comprising 4 distinct humps due to a longitudinal groove on each incisor and a medial notch between the incisors; ± straight lower incisor pairs 5.5–7.0 mm wide with 1 medial notch	rabbit/hare
	– Card margins cut or removed, with incisor-pair impression or puncture holes <2.6 mm when present	14
14	– Large areas of, usually, both sides of the card removed, and/or arching cuts up to 30 mm long at an angle of about 30°; cut edges jagged but not torn, ± incisor-pair impressions or puncture holes 1.6–2.5 mm wide close to the cut edges	rat
	– Small areas of, usually, one side of the card removed, and/or small, rough marginal cuts up to c. 5 mm long; ± incisor pair impressions or puncture holes <1.5 mm wide close to the cut edges	15
15	– Cut edges raised and ringed by numerous tiny partial incisor-pair impressions; ± incisor pair impressions or puncture holes 0.8–1.2 mm wide close to the cut edges	mouse
	– Small lengths of card margin or sections of card surface along one side of individual flutes torn or removed, affected edges very rough, with numerous tiny tears; usually numerous, faint, tiny (<0.3 mm diam.) circular impressions beside torn edges	Invertebrate
16	– Large tears on one or both surfaces of the card, initiated up to 40 mm in from the card margin	22
	– Puncture holes on one or both sides of the card, but only short tears (if present)	17
17	– Canine puncture holes on one or both surfaces of the card.....	18
	– Incisor-pair puncture holes on one or both surfaces, within 10 mm of the card margin...	23
18	– Small, oval, canine puncture holes or depressions in pairs 3.5–6 mm apart, on 1 surface, with blunt incisor-pair impression and/or crushing on the opposite surface	hedgehog
	– Circular canine puncture holes on both surfaces of the card.....	19
19	– Upper inter-canine distances ≥14.5 mm, ± card corners extensively chewed or missing .	cat/dog
	– Upper inter-canine distances <14.5 mm	20
20	– Upper inter-canine distances ≥10.0 mm	ferret

	– Upper inter-canine distances <10 mm	21
21	– Upper inter-canine distances ≥7 mm	stoat
	– Upper inter-canine distances <7 mm	weasel
22	– Tears initiated at sharp points that may penetrate both surfaces; distinctive, strongly curved impressions or dragged depressions, both 6 mm wide and without medial notches or ridges, on one side of the card	kea
	– Tears with blunt origins on one surface of the card; crushing on both surfaces with or without distinct incisor-pair impression, 4.5–7 mm wide, with medial notches	possum
23	– Incisor-pair puncture holes ± impressions both 1.8–2.5 mm wide.....	rat
	– Incisor-pair puncture holes ± impressions both 0.8–1.3 mm wide.....	mouse

Species descriptions

Possum: Most marks are made by an upper and lower pair of incisors. Card margins may or may not be (\pm) extensively crushed up to 30 mm in from the edge, on both surfaces, along one or both baited areas \pm extending along all margins and the fold line, and usually with, but occasionally without, distinctive, slightly curved incisor-pair impressions 4–7 mm wide within or beyond crushed areas. Incisor-pair impressions have a medial notch or gap, ranging from a small V-shaped notch to a gap up to 1 mm wide, and matched by tooth impressions on the opposite surface.

Upper incisor impressions usually have a shallow undulation one-half to two-thirds of the way to the lateral side, which is more pronounced in older animals. Impressions occasionally have shallow serrations or striations (parallel scrape marks) in young animals. The lower incisor-pair (mandible) impressions are more strongly curved, usually less distinct (blunt), about 1 mm wider, and 2 mm closer to the card margin than the upper incisor impressions.

Incisor-pair drag marks are common, usually forming broad channels with a longitudinal medial ridge. Alternatively, numerous, closely spaced, parallel incisor-pair impressions ('chattering') may be present, where a possum has repeatedly pressed down while performing a dragging motion. Very occasionally the upper incisors penetrate the card surface and partly peel it back.

One or a few light to heavy incisor-pair impressions may be present without any card crushing, requiring careful examination of cards that initially appear to be unmarked. Variable marks not characteristic of incisor-pair impressions are often present, and sometimes numerous, made by incisor teeth when the possum's head is tilted at a sharp angle to the card side (vertical and/or horizontal tilt), or by the premolar and canine teeth when the card corners are chewed in the side of the mouth.

Similar bite marks: see also hedgehog, rabbit/hare, kea and rat to distinguish visually similar bite marks.

Rabbit/hare: All marks are made by the sharp upper and lower incisors-pairs, which form straight impressions. Typically, large areas of the chewcard are cut away in broad arcs, bordered by a band of crushed card with numerous incisor impressions within and beyond the crushed zone.

The upper incisor-pair impressions consist of four humps in a straight line, spanning about 6 mm. The four humps arise from a medial notch between the two incisors and two additional notches formed by a longitudinal groove running the length of the anterior surface of each incisor. Lower incisor pairs lack longitudinal grooves so produce a 6 mm wide straight impression, bisected by one (medial) notch. Incisor-

pair impressions can be present without crushed or cut and missing areas. Rabbits and hares cannot be separated using bite marks on chewcards.

Similar bite marks: crushed areas may be visually similar to those made by possums, but can usually be distinguished from possums by areas of material removed (cleanly cut edges) and/or upper incisor-pair impressions showing four humps in a straight line. Lower incisor impressions of rabbits and possums are of similar size and form (both have one medial notch), but are separated by the very straight impressions in rabbits versus the strongly curved impressions in possums.

Hedgehog: Hedgehogs are unusual in that they leave canine impressions on one surface and blunt incisor-pair impressions on the opposite surface. Inter-canine distances are variable (c. 3–6 mm), and unlike the canines in other predators are distinctively oval rather than circular in cross-section. Canines will sometimes puncture the upper card surface, but usually form unbroken depressions within 25 mm of the card margin.

The lower jaw holds two blunt incisors, which are variable in size and separation. They range from stout pegs without a pronounced medial gap, to slender but blunt canine-like marks separated by up to 2 mm. Regardless of tooth size, the lower pair make blunt, paired impressions 3.0–4.0 mm wide, which, when extensive, result in a crushed card margin.

Similar bite marks: when hedgehog biting is extensive, the blunt incisors crush the card margins in a manner similar to possums. In these cases, the presence of only small, oval, canine teeth on one surface will separate hedgehog biting from that of possums.

Rat: All marks are made by an upper and lower pair of sharp incisors. Typically, large areas of card are cut away in variable patterns, often extending well beyond the baited areas, frequently including the fold line. Occasionally only one surface of the card is removed, or rough cuts up to 30 mm long are made without the card material being lost. Cut margins are jagged with, usually, a few clear incisor-pair impressions or puncture holes close to the cut edge.

Incisor-pair impressions and holes are 1.8–2.6 mm wide for European rats and 1.6–1.8 mm in kiore from Chatham Island. Upper incisor impressions are very similar in profile to those of possums, but are easily distinguished by size. Upper incisor puncture holes are almost straight, with square ends. Lower incisor impressions and puncture holes are much more curved than for the upper pair, often having as much depth as width. Lower incisor-pair impressions are about 0.2 mm narrower than upper impressions, and can often be seen on the upper incisor side of the card as a 'negative' impression (upward bump coming from below) immediately inside (closer to the card margin than) the upper incisor-pair impression.

Similar bite marks: confusion with mice can arise when card material is removed from just one side of the card, a feature typical of mouse chewing. In these cases, incisor-pair impressions greater than 1.5 mm in width, if present, and jagged cut edges without a narrow band of finely chewed material will confirm a rat detection. Where two clear rat upper incisor-pair impressions occur side by side, they can, together, appear very similar to a single possum incisor-pair. In this case, the medial notch in the centre of both halves of the putative possum bite will identify them as being rat. 'Negative' impressions (bumps) of the lower incisor teeth parallel to the upper impression, when present, will also confirm rodent detections.

Mouse: All marks are made by an upper and lower pair of sharp incisors. Typically, small areas of card are cut away from one surface of the card, leaving the internal partitions of the card. Cut edges are smooth relative to the jagged nature of rat chewing, with, usually, a slightly raised or rolled marginal band or flange of finely chewed material. This is usually fringed by numerous partial or complete incisor-pair impressions.

Incisor-pair impressions are very similar in shape to those of rats, but are identified as mouse by their smaller sizes. Upper incisor-pair impressions and holes are 0.7–1.4 mm wide, with lower incisor impressions about 0.1 mm narrower. Lower incisor impressions are often seen on the upper incisor side of the card as an upward impression (bumps coming up from below) immediately inside (closer to the card margin than) the upper incisor-pair impressions.

Similar bite marks: rats produce similarly shaped incisor impressions to mice, but the two species are separated by size: rat impressions are >1.5 mm wide and mice are <1.5 mm wide. Mouse chewing is superficially similar to (and often confused with) invertebrate chewing. Both mice and invertebrates commonly remove card material from between the flute partitions on one side of the card, make small rough cuts at the card margins, or leave very fine chew marks on the card margins without cutting the card surface. They can be separated on the basis that invertebrates create tattered edges when card material is torn or removed, and invertebrate jaws leave tiny (<0.3 mm), round impressions or narrow drag marks, while mouse bites have the broad impressions or drag marks typical of broad incisor teeth. Mice will sometimes remove bait material from the ends of the flutes without leaving tooth impressions, but may leave faint claw marks. These are difficult to distinguish from light invertebrate bite marks.

Predators (weasel, stoat, ferret, cat, dog): predator bite marks are dominated by or solely represented by circular canine puncture holes and depressions. Puncture holes can be extensive, forming continuous bands along card edges, or few and isolated. Canine teeth are usually splayed outwards (tip farther apart than bases) so that deep puncture holes are usually slightly torn or elongated. Incisor teeth in

predators are small and much shorter than the canines so usually do not form impressions. Carnassial teeth (large molars for cutting and tearing), which are pointed, are sometimes used when the animal chews the corner of the card in the side of its mouth (common in cats and probably dogs), resulting in torn or missing card corners.

These five species are distinguished by the upper jaw inter-canine distance (see 18–22 of the key), although there is some overlap between ferrets and cats. The cat database includes kittens as small as 780 g (inter-canine distance of 13.5 mm). Few kittens smaller than this are likely to be ranging far from their natal den. A database of dog inter-canine distances has not been compiled during this work, but most dogs will exceed the upper limit of 22 mm for cats. For example, one 8 kg male cairn terrier had an upper inter-canine distance of 31.5 mm. Inter-canine measurements are most accurate for light impressions or from the lower card surface, when the upper canines penetrate both surfaces of the card.

Kea: The tip of the upper bill of the kea is narrow, pointed and curved, and extends well beyond the lower bill, especially in mature males. This upper bill is capable of puncturing and tearing the card surface, often pushing through both card surfaces, and leaving one or both surfaces extensively torn. Where biting is light, the upper bill makes a slightly rounded, V-shaped impressions. The lower bill is broad and blunt, with its leading edge forming a smooth semicircle, c. 6 mm in diameter. Upper bill marks extend beyond (reach further across the card than) the lower bill impressions. Extensive biting can create large crushed areas, particularly if not much tearing occurs.

Similar bite marks: during extensive kea biting the lower bill can produce large crushed areas on one side of the card, similar to extensive possum chewing. Defined impressions within the crushed zone are also of similar size and shape to the lower incisor-pair of possums, but are distinguished from these by the absence of a medial notch. In these cases, extensive tears initiating from sharp points are usually also present on the opposite (upper) surface of the chewcard.

Weka: Weka peck at the flat surfaces of cards in a random fashion, producing a scattering of dents, about 4 mm wide, across the entire surface of the upper half of the card (down-folded portion). Impressions range from sharp and elongated, which may puncture the upper card surface, to blunt and rounded without penetrating the card surface. Few impressions are usual, but occasionally they are numerous. No other animal produces a similar pattern of scattered dents, but poor card handling may cause similar marks if the flat surface of the card is pressed against a hard, pointed surface.

Invertebrate: Invertebrates remove card material from between the flute partitions on one side of the card, make small rough cuts at the card margins, or leave very fine chew marks on the card margins without cutting the card surface. Finely tattered edges are produced when the card material is cut, torn or removed. Cut or torn edges are fringed by tiny (<0.3 mm) round impressions or narrow drag marks.

Similar bite marks: mice also remove material from between the card partitions on one side of the card and produce very small tooth impressions. Invertebrate bites are distinguished from mice by the rough, tattered nature of edges that are torn or cut, and the presence of single, mainly circular, tooth impressions resulting from the paired impressions of the broad incisors in mice. Rats can also remove material from just one side of a chew card, but this does not typically follow along individual flute channels as for mice and invertebrates, and rat-cut edges are jagged and on a much larger scale (texture) than the rough edges left by invertebrates.

Ungulate – ruminants (goat, deer, sheep, cattle) and pigs: large ungulates such as cattle can extensively chew cards, sometimes taking the entire card into the mouth and chewing it into a loose, crumpled ball before discarding it. In these cases, blunt, indistinct tooth impressions will cover both surfaces of the card, even for ruminants, which have no upper incisor teeth. Pigs (an ungulate but not a ruminant) can produce similar sign; their generally large mouths and blunt teeth make extensive indistinct impressions and crush marks. In these cases it may be impossible to tell pigs apart from a large ruminant.

Where distinguishable, isolated ungulate bites are more open to interpretation. Ruminants (goats, deer, sheep and cattle) lack incisor teeth in the upper jaw (skull). In their place there is a calloused pad, against which the incisor teeth of the lower jaw press during biting. There are eight broad, flat incisors, four on each jaw, which form a semi-circular arc of narrow tooth impressions, ranging from about 20 mm across in a 6-month-old sika fawn, to about 80 mm across in cattle. Bitten cards are often bent and/or pulled from their mounting nail.

In contrast, pigs have incisor teeth in both the skull (two incisors) and mandible (four incisors). Where pigs make just a few tentative bites, blunt circular or oval impression of two to four incisors in arcs of up to 25 mm across may be seen on both sides of the card. Pigs rarely bite cards, but where heavy sign matching that described above is seen in deep forest it is likely to be pigs, whereas on farmland it is likely to be cattle.