Table 1 Cautery disbudding methodologies reported in goat kid publications.

Age of animal (days)	Breed	Hair removal (Y/N)	Type of iron	Iron temperature (˚C)	Number of applications per bud	Total application per horn bud (seconds)	Horn bud removed (Y/N or both)	Reference
7-28	Saanen	NA	NA	NA	1	15-30	NA	Greenwood & Shutt (1990)
11-19	French Alpine, Saanen	Y	Electric – 220V	600*	3-4	9-16	N	Alvarez *et al* (2009)
<20	French Alpine, Saanen	Y	Electric	600*	3-4	9-16	N	Alvarez & Gutiérrez (2010)
13-21	Swedish Landrace	NA	Electric	600*	1	7-15	NA	Ingvast-Larsson *et al* (2011)
14-15	Beetal	NA	NA	NA	NA	NA	NA	Chandrahas *et al* (2013)

10-20	French Alpine, Saanen	NA	Electric – Lenk® 200GD	NA	3-4	6-16	Y	Alvarez *et al* (2015)
14-15	Beetal	NA	Manually heated	NA	NA	NA	NA	Chandrahas *et al* (2015)
4-9	Saanen, Nubian, Toggenburg, LaMancha, French Alpine	Y	Electric	295-326	1	4-7	NA	Nfor *et al* (2016)
2-6	Saanen, Saanen cross	Y	Electric – ‘Quality’ 230V	600*	1	≤8	Y	Hempstead *et al* (2017)
2-7	Saanen cross	Y	Electric – ‘Quality’ 230V	600*	1	≤6	Y	Hempstead *et al* (2018a)
9-14	Saanen, Saanen cross	Y	Electric – ‘Quality’ 230V	600*	1	5-7	Y	Hempstead *et al* (2018b, c)
2-10	Saanen	Y	Gas-powered – ‘Heavy Duty’	600*	1-4	~6	Y	Hempstead *et al* (2018d)

2-6	Saanen	Y	Electric – 'Quality' 230V	600*	1-5	~6	Both	Hempstead *et al* (2018e)
5-15	French Alpine, LaMancha, Saanen	Y	Electric – Rhinehart X-30	501	2-4	8-12	N	Alvarez *et al* (2019)

NA: not available as the information was not provided. * denotes studies that did not state if (or describe how) the temperature of the iron was measured.

Table 2 Cautery disbudding methodologies reported in calf publications.

Age of animal (weeks)	Breed	Hair removal (Y/N)	Type of iron	Iron temperature (˚C)	Total application per horn bud (seconds)	Number of applications per bud	Horn bud removed (Y/N)	Reference
8	Holstein	NA	Electric – Sunbeam 120V	NA	120-180	NA	NA	Laden *et al* (1985)
7-16	Holstein	NA	Electric – Sunbeam 120V	NA	120-180	NA	NA	Boandl *et al* (1989)
3-4	Holstein	NA	Electric – Rhinehart 110-120V	NA	10 and 60-120	1	NA	Wohlt *et al* (1994)
8	Mont-béliarde	NA	Electric	600*	~60	1	NA	Morisse *et al* (1995)
6-8	Friesian	NA	Gas-powered – Te Pari Products	NA	3-5	1	NA	Petrie *et al* (1996)
4-6	Brown Swiss, Holstein-Friesian, Jersey	NA	Electric – ‘Safety-First’ A-Super-Vario	600*	10-20	1	Y	Graf & Senn (1999)

4-6	Friesian	NA	Electric – Kruuse 190W	600*	15	1	NA	Grondahl-Nielsen *et al* (1999)
4-8	Holstein	NA	Electric – Rhinehart X30	600*	~35	1	NA	Faulkner & Weary (2000)
<1	Holstein	NA	Butane-powered – Portasol Dehorner II	593	NA	NA	NA	Milligan *et al* (2004)
3-9	Holstein	NA	Electric – Rhinehart X30	600*	19-52	NA	NA	Schwartzkopf-Genswein *et al* (2005)
1.4-5	Holstein	NA	Electric – Rhinehart X30	600*	~15	1	N	Vickers *et al* (2005)
10-12	Holstein	Y	Electric – Rhinehart X50	538	NA	NA	NA	Doherty *et al* (2007)
5-7	Holstein-Friesian	NA	Gas-powered – ABER LPG Debudder	NA	NA	NA	Y	Stewart *et al* (2008)
6-12	Holstein	NA	Electric – Rhinehart X30	600*	NA	NA	NA	Heinrich *et al* (2009)

4.3-5.6	Holstein-Friesian	NA	Gas-powered – ABER LPG Debudder	NA	NA	NA	Y	Stewart *et al* (2009)
4-8	Holstein	NA	Electric – Rhinehart X30	600*	NA	NA	NA	Duffield *et al* (2010)
4.7-5.9	Holstein	NA	Butane-powered	NA	20-30	1	NA	Stilwell *et al* (2010)
6-12	Holstein	NA	Electric – Rhinehart X30	600*	NA	NA	NA	Heinrich *et al* (2010)
8-10	NA	NA	Electric	NA	~30	1	N	Stilwell *et al* (2012)
10	Holstein	NA	Electric – Rhinehart X30	600*	20	1	NA	Theurer *et al* (2012)
8-10	Holstein	NA	Electric – Rhinehart X30	600*	NA	NA	NA	Allen *et al* (2013b)
5-8	Simmental, Brown Swiss, or Holstein-Friesian	NA	Electric –Kerbl	NA	NA	NA	Y	Huber *et al* (2013)
4-5.5	Holstein–Friesian	NA	Gas-powered – ABER LPG Debudder	NA	NA	NA	Y	Mintline *et al* (2013)

<1	Holstein	NA	Electric – Rhinehart X30	NA	15	1	NA	Neave *et al* (2013)
5	Holstein-Friesian	NA	Gas-powered – ABER LPG Debudder	NA	~49	NA	Y	Stewart *et al* (2013)
1-2	NA	NA	NA	NA	NA	NA	NA	Hokkanen *et al* (2014)
3-6	Friesian-Jersey	NA	Gas-powered	NA	12-15	NA	Y	Bates *et al* (2015)
1-4	Charolais, Holstein	Y	Butane-powered – Buddex™, Kerbl	700*	7	1	NA	Caray *et al* (2015)
6-8	Holstein-Friesian		Electric	600*	30-60	NA	NA	Korkmaz *et al* (2015)
4-6	Holstein	NA	Butane-powered – Express dehorner	600*	~10	1	N	Stock *et al* (2015)
3-6	Friesian-Jersey	NA	Gas-powered	NA	12-15	1	Y	Bates *et al* (2016)
7-8	Holstein	NA	Electric – Rhinehart X30	600*	15-20	NA	N	Stock *et al* (2016)

2-5	Holstein, Jersey-Holstein	NA	Electric – Rhinehart X50	NA	10-20	NA	NA	Black *et al* (2017)
1-3	Holstein	Y	Butane-powered – Portasol	NA	≤5	1	Y	Huebner *et al* (2017)
6-8	Holstein	NA	Dehorner III Electric - Rhinehart	NA	10	1	N	Kleinhenz *et al* (2017)
<5	Holstein, Jersey	Y	Electric – Rhinehart X50	467	18-23	NA	N	Adcock & Tucker (2018)
6-8	Holstein	NA	Electric - Rhinehart	NA	10	1	N	Kleinhenz *et al* (2018)
1-4	Holstein	NA	Electric - Lötkolben 230 V	600*	NA	NA	NA	Mirra *et al* (2018)
3-4	Friesian	NA	Electric – ‘Quality’ 230V	NA	NA	NA	Y	Sutherland *et al* (2018a)
<1.5	Holstein	Y	Electric – Rhinehart X50A; Butane-powered – Portasol	433-436	7-25	NA	N	Adcock *et al* (2019)

4-5	Friesian	NA	Butane-powered – Portasol Mark 3 debudder	NA	10-15	NA	Y	Bates *et al* (2019)
4-7	Holstein	NA	Gas-powered – Express dehorner	NA	5-7	1	Y	Byrd *et al* (2019)
1-4	Holstein	NA	Electric	NA	NA	NA	NA	Casoni *et al* (2019)
2-6	NA	Y	Gas-powered – Express dehorner	NA	NA	NA	Y	Cuttance *et al* (2019)
3-7	Holstein	Y	Electric – Rhinehart X30	500*	15	NA	NA	Ede *et al* (2019a)
3-5	Holstein	NA	Electric – Rhinehart X30	NA	NA	NA	NA	Ede *et al* (2019b)
1-5	Holstein	NA	Electric – Rhinehart X30	NA	15	NA	NA	LeCorps *et al* (2019)
10	NA	NA	Electric	NA	10	1	N	Mir *et al* (2019)
<1	Friesian	Y	Electric – ‘Quality’ 230V	NA	15	NA	Both	Sutherland *et al* (2019a)

NA: not available as the information was not provided. * denotes studies that did not state if (or describe how) the temperature of the iron was measured.

Table 3 Comparison of specific behavioural responses (increase or no change) of goat kids and calves *during* cautery disbudding. The group that is compared to cautery disbudding and the observation duration of each study is also presented. Note: when the cautery disbudded animals are treated (eg with lidocaine), this is denoted by a superscript located in the comparison group column and is described in the footnote.

Species	Struggle	Vocalise	Leg movement	Tail shake	Head movement	Rear/ trip/fall	Comparison group	Restraint method	Reference
Goat kids		+					Simulated disbudding	NA	Greenwood & Shutt (1990)
	+	+					Simulated disbudding	Manually held and head restrained	Alvarez *et al* (2009)
		+	+				Simulated disbudding	Manually held and head restrained	Alvarez & Gutiérrez (2010)
		+	+				Disbudding + lidocaine + meloxicam	NA	Chandrahas *et al* (2013)
	+	+		N			Simulated disbudding	Gently held on	Alvarez *et al* (2015)

								lap of operator Head restrained and legs loosely held	
		+	+				Simulated disbudding		Nfor *et al* (2016)
	N	N		+	N	+	Simulated disbudding	Manually restrained against wall	Graf & Senn (1999)
			+		+		Simulated disbudding + lidocaine	NA	Grondahl-Nielsen *et al* (1999)
Calves	+*	N	+*			+*	Simulated disbudding	Head bail	Stewart *et al* (2008)
			+				Simulated disbudding+ lidocaine[a]	Chute	Doherty *et al* (2007)
	+						Simulated disbudding +	Restrained lying down	Stilwell *et al* (2010)

				saline + lidocaine[b]		
+	+		N	Simulated disbudding[c]	Chute	Caray *et al* (2015)
+				Simulated disbudding	Calf crate	Bates *et al* (2019)

+: increased in response to disbudding, N: no change in response to cautery disbudding, blank: was not assessed, NA: not available. * No differences in individual behaviours were observed, but behaviours were combined together to give a single measure of activity. Cautery disbudded calves were administered [a]saline, [b]xylazine and saline and [c]ketoprofen.

Table 4 Comparison of specific behavioural responses (increase, decrease or no change) of goat kids and calves *following* cautery disbudding. The group that is compared to cautery disbudding and the observation duration of each study is also presented. Note: when the cautery disbudded animals are treated (eg with lidocaine), this is denoted by a superscript located in the comparison group column and is described in the footnote.

Species	Head shake	Head rub	Head scratch	^Stand/ lie bouts	Feed	Groom	Mouth movement	Ear flick	Kick/ buck	Comparison group	Observation duration	Reference
Goat kids	+									Simulated disbudding	3 h	Greenwood & Shutt (1990)
	+*		N	+*	N		+*			Disbudding + meloxicam	2 h/day for 4 days	Ingvast-Larsson *et al* (2011)
				+	+	+	+			Disbudding + lidocaine	5 h over 24 h	Chandrahas *et al* (2013)
	+	+	+		N	N	N			Simulated disbudding	12 h	Hempstead *et al* (2017)
	+		+	N	N	N				Simulated disbudding	24 h	Hempstead *et al* (2018a)

	N		N	N	N	N			Simulated disbudding	1 h	Hempstead *et al* (2018c)
	+	-	+	+		-			Disbudding + lidocaine	Up to 24 h	Morisse *et al* (1995)
	+	N			-				Simulated disbudding	4 h	Graf & Senn (1999)
	+						+	+	Simulated disbudding + lidocaine	4 h	Grondahl-Nielsen *et al* (1999)
Calves	+	+		N	N	N	+		Disbudding + ketoprofen[a]	2.5 h over 24 h	Faulkner & Weary (2000)
	+	+		+					Caustic paste disbudding + xylazine[b]	12 h	Vickers *et al* (2005)
				N	N	N			Simulated disbudding+ lidocaine[c]	72 h	Doherty *et al* (2007)
					N	N		+	Simulated disbudding	40 min	Stewart *et al* (2008)

+*	+*		N	N	N		+	Disbudding + lidocaine + ketoprofen[d]	7 h	Duffield *et al* (2010)
+	N		+				+	Simulated disbudding + saline + lidocaine[e]	20 min over 1 h	Stilwell *et al* (2010)
+	N			N			+	Disbudding + meloxicam + lidocaine[f]	10 h over 48 h	Heinrich *et al* (2010)
			-					Disbudding + meloxicam[c]	7 days	Theurer *et al* (2012)
	N						-	Simulated disbudding + saline[c]	24 h	Mintline *et al* (2013)
	N						N	Simulated disbudding[g]	15 min	Caray *et al* (2015)
N	N	N	N		N		N	Simulated disbudding + lidocaine +	1 h over 24 h	Mirra *et al* (2018)

					xylazine + meloxicam[h]		
			-		Simulated disbudding	24 h	Sutherland *et al* (2018a)
+	N	N		N	Simulated disbudding	3 h	Bates *et al* (2019)
-		-		-	Disbudding + Tri-Solfen meloxicam + lidocaine[f]	24 h	Cuttance *et al* (2019)

+: increased in response to disbudding, -: decreased in response to disbudding, N: no change in response to cautery disbudding, blank: was not assessed. [^]Refers to the number of transitions between standing and lying. *No differences in individual behaviours were observed, but behaviours were combined together to give a single measure of activity. [a]Both cautery disbudded and control animals were administered xylazine and lidocaine. Cautery disbudded calves were administered [b]xylazine and lidocaine, [c]saline, [d]lidocaine and saline, [e]xylazine and saline, [f]lidocaine and a placebo solution, [g]ketoprofen, or [h]xylazine, lidocaine and meloxicam.