Tail length in unmulesed Australian Merino sheep

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Joan Lloyd
Consulting Pty Ltd

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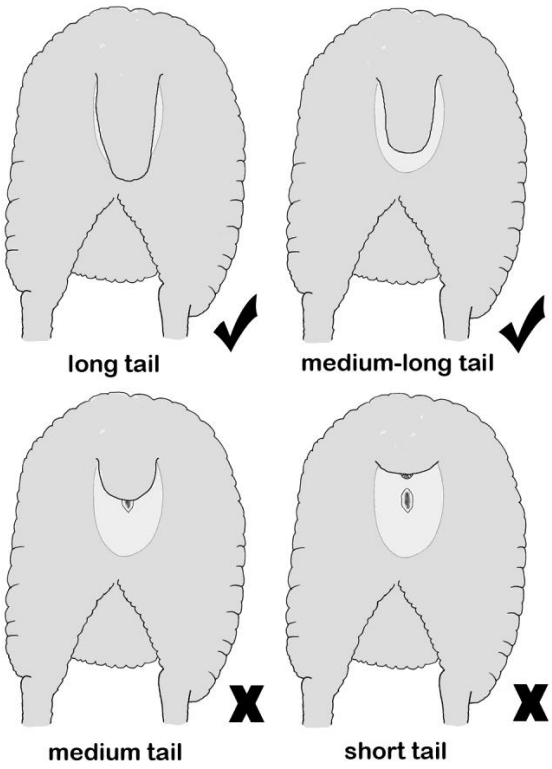
Executive summary

The docking of lambs' tails is a long-standing practice used to reduce the life-long susceptibility of sheep to breech fly strike. This review addresses the impact of tail length on susceptibility to breech fly strike of unmulesed Australian Merino sheep. The acute welfare impacts of docking of the different tail lengths or by different methods (cold knife, rings, hot/gas docking knife) was not part of the review.

The move back to unmulesed sheep has resulted in some producers questioning the current recommendation for tail length, perhaps because they do not realise that this recommendation is largely based on extensive research carried out on unmulesed sheep during the 1930s and 1940s. Some people also think that mulesing, tail stripping or leaving a 'V' of wool-bearing skin on the dorsal surface of the tail leads to shortening of the tail due to contraction of scar tissue. Because of this, some people think that unmulesed sheep should have their tails docked to a shorter initial length.

The review was a desktop review of the published literature. The majority of the published information on tail length in unmulesed Australian sheep was published during the 1930s and 1940s and not readily found by searching electronic databases. Instead, information was mainly located by tracking cited references.

Six studies that investigated the most appropriate tail length for unmulesed Merino sheep were conducted during the 1930s and 1940s These studies included more than 10,000 sheep on five properties in eastern Australia and clearly demonstrated that docking the tails of unmulesed Merino sheep either medium-long (extending to just below the tip of the vulva in ewes and an equivalent length in wethers) or long (at the fourth joint or to give a 3.75-4 inch/9.4-10 cm tail that extended just below the lower border of the natural bare area) gave better protection against breech fly strike than docking to give a medium length (2 inches/5 cm long or tip opposite the vulva orifice) or short (tail tip not extending below the top of the vulva) tail. Leaving the tail undocked also provided better protection against breech fly strike than docking to give a medium length or short tail.



Docking the tails of unmulesed sheep at the second joint or shorter resulted in an inferior result, with these animals experiencing two to three times the rate of breech fly strike as sheep with the tails docked long or medium-long.

Short and medium length tails took longer to heal than medium-long or long tails and were more likely to be infected. Healing was also prolonged in older lambs, with higher rates of infection.

The evidence to support the contention that, when docked to the same length, mulesed sheep tend to have a shorter tail than unmulesed sheep was not compelling. Regardless, this review has revealed that a long tail in unmulesed sheep actually gave the best protection against breech fly strike, but was rejected for other reasons, i.e. it was inclined to stick up or out and was more difficult to shear or crutch. If shorn or crutched carefully, a long tail may not provide a disadvantage in terms of protection against breech fly strike.

One issue that was not conclusively resolved during this early research was the relationship between tail length in unmulesed sheep and dag formation, with the studies largely conducted in low-dag environments. One of the studies suggested that wethers with long tails were less susceptible to dag formation than wethers with short tails; however, numbers were considered too small to provide conclusive evidence. In another, dag formation increased as tail length increased, but the sheep with medium-long or long tails were still less susceptible to fly strike than those with short and medium length tails.

Subsequent research in the 1970s revealed that scouring, unmulesed sheep with short tails are susceptible to breech fly strike.

Introduction

This review addresses the impact of tail length on susceptibility to breech fly strike of unmulesed Australian Merino sheep. The docking of lambs' tails is a time-honoured practice (Joint Blowfly Committee, 1940), used to reduce susceptibility to breech fly strike and to improve the ease of shearing and crutching.

The length of the docked tail influences lifelong susceptibility to breech fly strike in sheep and therefore has lifelong consequences for animal welfare. The current recommendation for ewe lambs is to dock the tail immediately below the third palpable joint or through the third joint space (the so called medium-long tail), and was first published in 1943 (Joint Blowfly Committee 1943), based on research with both unmulesed and mulesed sheep (Gill and Graham 1938; Gill and Graham 1939; Riches 1941; Graham *et al.* 1941; Riches 1942; Johnstone 1944). Male lambs should have their tails docked to the same length as ewe lambs. This will result in the healed tail protecting the anal region and extending to the around the tip of the vulva in ewes.

A medium-long or long tail heals faster after docking than a short tail, and is less prone to infection and flystrike (Johnstone 1944; Watts *et al.* 1979). Short tails predispose lambs to rectal prolapse (Thomas *et al.* 2003) and, later in life, to squamous cell carcinoma of the perineal region (Swan *et al.* 1984).

The move back to unmulesed sheep has resulted in some producers questioning the current recommendation for tail length, perhaps because they do not realise that this recommendation is largely based on extensive research carried out on unmulesed sheep during the 1930s and 1940s (Gill and Graham 1938; Gill and Graham 1939; Riches 1941; Riches 1942; Johnstone 1944; Graham and Johnstone 1947a). Some people also think that mulesing, tail stripping or leaving a 'V' of wool-bearing skin on the dorsal surface of the tail leads to shortening of the tail due to contraction of scar tissue. As a result, it is suggested that when tails have been docked at the same initial length the tails of mulesed sheep end up shorter than the tails of unmulesed sheep. It is therefore suggested that the tails of unmulesed sheep should be docked shorter than the current recommendation. In support of this viewpoint, research comparing a number of different tail lengths and radical mulesing methods in the late 1970s and early 1980s suggested that when docked to the same length, radically mulesed sheep tended to have shorter tails than unmulesed sheep (O'Halloran *et al.* 1984). However, the sheep in this study underwent either the radical Mules, or variants thereof, rather than the mulesing method currently recommended (Evans 2006), and differences were not evident with all the radical Mules methods tested and were not always significant.

When the studies in unmulesed sheep were conducted the susceptibility of sheep to fly strike was determined on a three point scale based on the degree of wrinkling of the tail, sides of the breech and crutch as described by Seddon *et al.* in 1931:

- A class sheep = plain-breeched, relatively no predisposition to breech fly strike
- B class sheep = intermediate level of breech wrinkle, partially predisposed the breech fly strike
- C class sheep = wrinkled breech, predisposed to breech fly strike (Seddon *et al.* 1931; Seddon 1931; Joint Blowfly Committee 1940).

The early research was conducted before the surgical operations to control tail strike were first described (Graham and Johnstone 1947b). The studies also preceded the availability of DDT and BHC during the late 1940s, with the use of these chemicals becoming more widespread in the 1950s and later replaced with aldrin, dieldrin and diazinon as these chemicals became available (Morley and Johnstone 1984). The highly improved pastures that can lead to dag formation were also not in existence at the time the studies were conducted.

Several different tail lengths were described and tested, as shown in Figure 1. These included:

- long tails – about 3.75-4 inches (9.4-10 cm) long or the end of the tail extending half an inch (12.5 mm) below the lower border of the bare area
- medium-long tail – end of the tail just below the lower commissure of the vulva but not extending beyond the lower border of the bare area
- medium tails – about 2 inches (5 cm) long or the end of the tail opposite the mid-point of the vulva orifice but not extending below the lower commissure
- short tails – not extending below the upper commissure of the vulva. In some studies the lambs were docked level with the buttocks.

Undocked tails were also investigated.

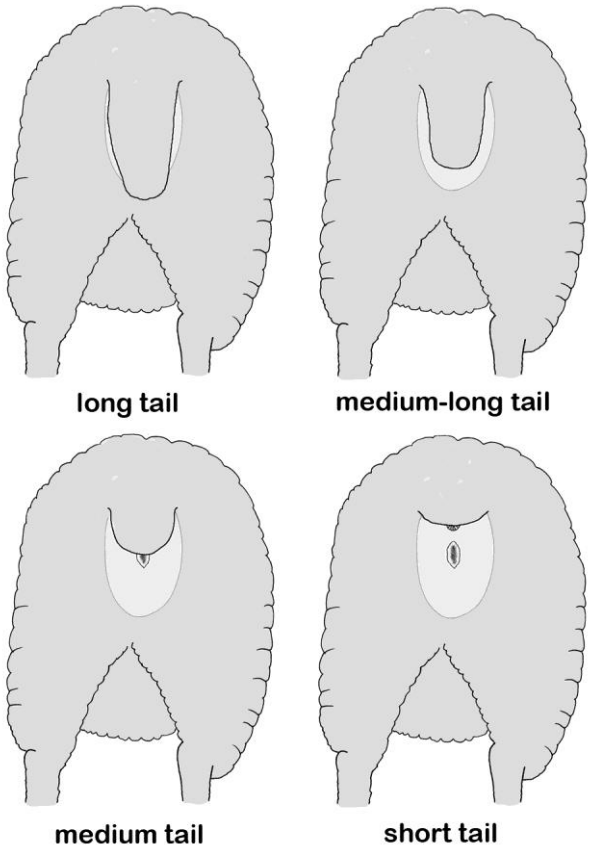


Figure 1. Tail lengths tested in research conducted on the relationship between tail length and the susceptibility of unmulesed sheep to breech fly strike during the 1930s and 1940s

Several criteria were used to assess the effectiveness of the four tail lengths, including:

- incidence of fly strike
- dag formation
- urine staining
- rate of healing of tail docking wounds
- infection of tail docking wounds
- conformation of the tail stump
- ease of shearing.

In most of the early studies the method of tail docking was not described. It is assumed that the method used was that in most common use at the time: knife, with the tail bent around the knife during the cut and the knife pushed forward towards the base of the tail to obtain a flap of skin on the ventral margin of the tail stump (Johnstone 1944). Although the searing iron for tailing lambs was described in Australia in the late 1930s (Filmer 1938), the use of rubber rings for marking lambs were not trialed in Australia until the late 1940s (Anon. 1947; Sinclair *et al.* 1950). The use of mulesing shears to dock tails was not practiced until mulesing was more widely adopted, probably coming into favour because it meant producers did not have to stop to change implements (Swan *et al.* 1980). However, even then the use of shears was not recommended because of the association with deviated and misshapen tails caused by coccygeal dislocation or fractures, or severing of the lateral coccygeal ligaments (Swan *et al.* 1980).

Because of the time that has elapsed since the early studies on tail length in unmulesed sheep were published, many have forgotten of their existence. This report summarises the published papers that report the findings of these early studies. It also briefly discusses later research on appropriate tail length in mulesed sheep.

This report refers to three types of fly strike: 1) crutch strike, which involves the region below the tail base along both sides of the perineal bare area to the udder or scrotum; 2) tail strike, which involves the tail; 3) breech strike, which is a collective term for crutch and tail strike (Watts and Perry 1975).

Summary of studies with unmulesed sheep conducted during the 1930s and 1940s

During the 1930s and early 1940s several studies were conducted on the relationship between tail length and the susceptibility of sheep to breech fly strike. At that time the Mules operation was also being investigated, and several of the studies included comparisons of mulesed and unmulesed sheep with varying tail lengths. The results from the unmulesed sheep in these studies are discussed in this section of the report, in chronological order as list in Table 1. In the majority of the studies the results of statistical analyses of the results were not reported by the authors.

Table 1. Summary of studies conducted on the relationship between tail length and the susceptibility of sheep to fly strike during the 1930s and 1940s

	Location	Year	Reference
Study 1	Dungalear (near Walgett NSW)	1937	Gill and Graham 1938; Gill and Graham 1939
Study 2	Gilruth Plains (near Cunnamulla, QLD)	1939	Riches 1941; Riches 1942
Study 3	Gilruth Plains (near Cunnamulla, QLD)	1939	Riches 1941; Riches 1942
Study 4	Gilruth Plains (near Cunnamulla, QLD)	1940	Riches 1942
Study 5	Gilruth Plains (near Cunnamulla, QLD)	1941, 1943	Johnstone 1944
Study 6	Five sites in NSW and QLD	1943-1945	Graham and Johnstone 1947a

When first under investigation, the Mules operation was divided into four parts:

i. Removal of wrinkles
ii. Treatment of 'scabby ulcer' of the vulva
iii. Straightening deflected vulvae surgically
iv. Cutting the tail short i.e. above the upper commissure of the vulva (Beveridge 1935).

Mules advocated cutting the tail short so urine from the tip of the vulva did not wet the underside of the tail (Beveridge 1935) and because it was thought that longer tails pressed on the vulva, causing the tip to become deflected to one side or the other (Gill and Graham 1939). At the time, lambs were most commonly docked with a short tail that did not extend below the midpoint of the vulva orifice, although it is reported that some observant producers questioned whether this predisposed sheep to fly strike (Riches 1941).

Study 1

Study 1 was conducted at Dungalear Station (near Walgett NSW) as part of a larger study investigating the effectiveness of the Mules operation (Gill and Graham 1938; Gill and Graham 1939). Only the results from the unmulesed sheep are discussed here. The study included Merino ewe weaners (born in November-December 1936) and ewe hoggets (born in November-December 1935). The sheep were shorn in June 1937 and crutched in July, the day before the study started.

Table 2. Study 1: Management of sheep

Shearing	Crutching	Date study commenced	Date fly strikes recorded
June 1937	July 11, 1937 October 11, 1937	July 1937	July - October, 1937

Observations were carried out to determine the correlation between tail length and crutch strike. For these purposes the sheep were divided into the following tail length groups:

- Long – the tail extended below the tip of the vulva
- Medium – the tail extended below the upper commissure but not below the tip of the vulva
- Short – the tail was cut off above the upper commissure of the vulva.

Fly strikes were recorded over a three month period from July to October 1937. There was a moderately severe fly wave during September and October.

Results are shown in Table 3. The rate of crutch strike was highest in sheep with short tails.

Table 3. Study 1: Association between tail length and crutch fly strike. Source: Gill and Graham 1939

Tail length	Number of sheep‡	Struck on crutch	Percent sheep struck	Number of strikes	Strikes per struck sheep
Long	31	9	29.0*	27	3.0
Medium	93	42	45.2	111	2.7
Short	182	99	53.6*	268	2.7

‡ Numbers in each group differ because the study was not a prospective study of 3 tail lengths applied at marking but a classification of tail length resulting from variation in tail length some months later.
* Difference is statistically significant

These observations prompted other researchers to set up a series of experiments during the late 1930s and early 1940s with the objective of examining the relationship between tail length and breech fly strike. Several of these involved unmulesed sheep.

Study 2

In November 1939 a research trial was established in Merino sheep at Gilruth Plains (near Cunnamulla, QLD) to examine the effect of tail length on crutch and tail strike (Riches 1941; Riches 1942). Three hundred and eighty seven ewe lambs were included in the study divided into three groups:

i. Long tails –131 lambs, tails docked at the fourth joint so tail stump was approximately 4 inches (10 cm) long

ii. Medium tails –128 lambs, tails docked at the second joint so tail stump was approximately 2 inches (5 cm) long with the tip reaching to about the mid-point of the vulva orifice

iii. Short tails –128 lambs, tails docked at the level of the buttocks.

A group with tails docked to the currently recommended length (medium-long) was not included in this study.

Approximately equal numbers of A, B and C class lambs were included in each tail length group (32-37 A class lambs, 56-66 B class lambs, 30-33 C class lambs). Management procedures during the study are shown in Table 4.

Table 4. Study 2: Management of sheep

Date study commenced	Crutching	Shearing	Classing	Time periods fly strikes recorded
November 1938 (lamb marking)	22 May 1939	August 1939 July 1940	March 1940	November 1938-May 1939 May– August 1939 August 1939 – March 1940 March – July 1940 July 1940 – January 1941 January – July 1941

The incidence of fly strike over the next two years is shown in Table 5. These results clearly demonstrate that a long tail was more effective than a medium or short tail at decreasing susceptibility to breech fly strike and that the effect was permanent, at least for the duration of this study.

After shearing in August 1939 the sheep were reclassified on breech conformation. The distribution of A, B and C class sheep within the tail length groups was still very similar (8-12 A class lambs, 50-63 B class lambs, 42-52 C class lambs) and the authors concluded that the higher incidence of fly strike in the medium and short-tailed groups was not due to a preponderance of B and C class sheep. (They also commented that animal numbers were lower at this time than at the start of the study because of short mustering.)

The long tail reduced the susceptibility to fly strike affecting either the tail or crutch or the whole breech region (Table 6).

Table 5. Study 2: Breech fly strikes per one hundred sheep in sheep with long, medium or short tails at various intervals from marking in November 1938 to shearing in July 1941. Source: Riches 1942

Interval	Breech fly strikes per 100 sheep		
	Long tail	Medium tail	Short tail
From marking November 1938 to crutching 23 May 1939	32.2	55.9	61.0
From 23 May 1939 to shearing 23 August 1939	5.0	17.0	19.0
From 23 August 1939 to classing 20 March 1940	2.0	0.0	2.0
From 20 March 1940 to shearing 17 July 1940	1.0	7.0	8.0
From 17 July 1940 to crutching 20 January 1941	0.0	0.0	0.0
From 20 January 1941 to shearing 17 July 1941	13.7	33.3	50.7

Table 6. Study 2: Number and location of breech fly strikes in sheep with long, medium and short tails. Source: Riches 1941; Riches 1942

Interval	Site of strike	Number of strikes		
		Long tail	Medium tail	Short tail
November 1938-July 1940	Tail only	2	5	6
	Tail and crutch (tail separate)	4	9	8
	Tail and crutch (continuous)	10	17	27
	Crutch only	31	60	62
	Total	*47*	*91*	*103*
January – July 1941	Tail only	1	2	7
	Tail and crutch	0	5	8
	Crutch only	9	15	20
	Total	*10*	*22*	*35*

Study 3

The third study commenced in November 1939, also at Gilruth Plains, and was part of a larger study in which some of the sheep were also mulesed (Riches 1941; Riches 1942). The study included 644 sheep with either long, medium or short tails as described for Study 2 and an undocked group. A group with tails docked to the currently recommended length (medium-long) was not included in this study. The papers did not clearly state if the data provided was for the unmulesed control sheep, but the data presented suggests that the sheep were unmulesed because of the high rate of fly strike. The breech wrinkle class of the lambs was not provided.

Conditions were extremely dry until the beginning of January 1941 and no strikes were recorded until the drought broke in January 1941. The sheep were crutched on 29th and 30th January 1941 and the strikes recorded are shown in Table 7, compared to the number of strikes at shearing 6 months later on 19th July 1941.

Table 7. Study 3: Breech fly strike incidence in sheep with varying tail lengths at crutching in January 1941 and at shearing in July 1941. Source: Riches 1942

	Tail length			
	Long	Medium	Short	Undocked
Number of sheep 20 January 1941	166	161	160	157
Number of strikes 20 January 1941	14	45	57	19
Strikes per 100 sheep	8.4	27.9	35.0	12.1
Number of sheep 19 July 1941	157	138	135	155
Number of sheep struck between 20 January and 19 July 1941	24	57	81	46
Percent of sheep struck	15.3	41.3	60.0	29.7
Number of strikes	39	84	122	64
Strikes per 100 sheep	24.8	60.9	90.4	41.3

The results clearly demonstrate that a long tail was more effective than a medium or short tail at decreasing susceptibility to breech fly strike. In addition, in this study, an undocked tail gave a superior result to tails docked either short (at the level of the buttocks) or to produce a two inch (5 cm) tail (docked at the second joint). The location of the strikes is shown in Table 8.

It is interesting to note that, in a study reported in 2000, there were no detrimental effects during processing of cross-bred lambs with undocked tails and no penalties were incurred by these lambs, which had all been sold direct to abattoir (Webb Ware *et al.* 2000).

Table 8. Study 3: Number and location of breech fly strikes observed between January and July 1941. Source: Riches 1942

Location of strike	Number of fly strikes			
	Long tail	Medium tail	Short tail	Undocked tail
Tail only	0	3	7	12*
Crutch and tail	9	12	29	25
Crutch only	30	69	86	27

* Considerable number of these strikes located about half-way down the tail at a point that would be absent from the long tail.

Based on these results, the authors felt confident to conclude the following (Riches 1942):

a) "That the long, four-inch tail has given very considerable reduction of susceptibility to strike as compared with the orthodox medium tail.

b) That a very short tail increases susceptibility to strike to an appreciable extent.

c) That the reduced incidence of strike in the longer tailed group is not due to a reduction in tail strikes only, but also to reduction in the number of pure breech[1] strikes."

Study 4

The fourth study was also at Gilruth Plains (Graham *et al.* 1941; Riches 1942). It commenced in October 1940 and was again part of a larger study in which some of the sheep were mulesed. It involved 209 ewe lambs and 199 wether lambs with either long (i.e. 4 inches or 10 cm) or short (i.e. about 1 inch or 2.5 cm) tails. A group with tails docked to the currently recommended length (medium-long) was not included in this study. The paper did not clearly state if the data provided was for the unmulesed control sheep, but the data presented suggests that the sheep were unmulesed because of the high rate of fly strike. The breech wrinkle class of the lambs was not provided.

No fly strikes were recorded between marking in October 1940 and crutching in January 1941. After crutching there was a fair amount of fly activity and fly strike (Table 9). These results support the earlier findings that a long tail is more effective than a short tail at decreasing susceptibility to fly strike in ewes.

[1] According to the classification system of Watts and Perry 1975, the use of breech strike in this instance probably refers to crutch strike, involving the region below the tail base along both sides of the perineal bare area to the udder or scrotum.

Table 9. Study 4: Breech fly strike incidence in ewe and wether weaners 1 January-23 May 1941. Source: Riches 1942

	Ewes		Wethers	
	Long tail	Short tail	Long tail	Short tail
Number of sheep at 23 May 1941	104	105	102	97
Number of sheep struck	19	46	2	3
Percent of sheep struck	18.3	43.8	2.0	3.1
Number of strikes	20	59	2	3
Strikes per 100 sheep	19.2	56.2	2.0	3.1

In April 1941 a number of sheep required dag removal, including 6.5% of the wethers with long tails and 10% of the wethers with short tails. None of the ewes required dag removal. The feed reportedly dried off quickly and no further dag removal was required. The numbers of sheep requiring dag removal were considered to be too small to provide conclusive evidence that sheep with long tails were less prone to dag formation than sheep with short tails.

The higher rate of dag formation in wethers than ewes was again observed and investigated during the 1970s and is thought to be due to the smaller natural perineal bare area in wethers than ewes (Morley *et al.* 1976; Watts and Marchant 1977; Watts and Luff 1978; Watts *et al.* 1978).

Study 5

The fifth study included two experiments, one that started in November 1941 and involved 254 wether lambs, and a second that started in November 1943 and included 138 ewe lambs (Johnstone 1944). Both experiments were conducted at Gilruth Plains.

In the first experiment the lambs had their tails docked at three different lengths:

- Long – tail stump left about 4 inches (10 cm) long at marking.
- Medium – tail stump left about 2 inches (5 cm) long at marking.
- Short – tail cut about half an inch (12.5 mm) below the anus.

In the second experiment the lambs had their tails docked at two different lengths:

- Medium-long – tail tip was level with the lower border of the bare area, i.e. about half an inch (12.5 mm) below the tip of the vulva.
- Short[2] – tail tip just above the top of the vulva.

The lambs were not mulesed.

As well as tail length, a number of other tail docking technique variations were investigated, including whether the tail was held straight or bent around the knife, whether a flap of skin was left at docking and whether the cut was made through a joint or coccygeal vertebra.

In the first experiment the tails were docked with the tail held straight out in line with the body and a flap of skin obtained by pushing the skin forward with the thumb before making the cut. In the second experiment the tails were docked with the tail either held straight as described for the first experiment or with the bent around the knife to obtain the flap of skin.

Observations did not include the incidence of fly strike; instead observations included rapidity of healing, infection, anatomical factors affecting healing and subsequent conformation of the tail stump. Only the findings associated with tail length are discussed in detail here.

Rapidity of healing

Tables 10 and 11 summarise the degree of healing ten or eight days after marking in Experiments 1 and 2 respectively. In Experiment 1 tails docked long healed the fastest. In Experiment 2 tails docked medium-long healed faster than tails docked to the medium length. There was no appreciable difference in the rate of healing when the tails were docked through a joint or through a vertebra. The authors commented that this was fortuitous, because considerable care is required to dock through a joint, with the shape of the coccygeal vertebrae resulting in the knife slipping off the joint in most cases and passing through the bone. Although the results did not permit a definitive conclusion, leaving a flap of skin seemed to provide an advantage in terms of rapid closure of the wound.

[2] Referred to as medium in the paper that described this study.

Table 10. Study 5: Experiment 1, Degree of healing of tail wounds 10 days after marking. (Degree of healing using an eight-point scale in which 8 represented complete healing, 1 no healing and numbers in between equal gradations between complete and no healing). Source: Johnstone 1944

Tail length	Location of cut	Skin flap	Number of lambs	Degree of healing
Long	Joint	Yes	23	7.8
		No	25	7.6
	Vertebra	Yes	23	7.8
		No	11	7.8
Medium	Joint	Yes	25	5.6
		No	24	6.5
	Vertebra	Yes	22	6.1
		No	23	6.0
Short	Joint	Yes	16	4.3
		No	12	4.4
	Vertebra	Yes	14	5.1
		No	12	3.6

Table 11. Study 5: Experiment 2, Degree of healing of tail wounds 8 days after marking. (Degree of healing using an eight-point scale in which 8 represented complete healing, 1 no healing and numbers in between equal gradations between complete and no healing). Source: Johnstone 1944

Tail length	Position of tail	Skin flap	Number of lambs	Degree of healing
Medium-long	Bent	Yes	23	5.9
	Straight	Yes	19	5.5
		No	18	5.1
Short	Bent	Yes	25	5.3
	Straight	Yes	20	4.8
		No	20	4.7

In Experiment 1 the approximate age at marking was estimated based on the size of the lambs (large – about 6-10 weeks old, medium – about 3-6 weeks old, small – up to 3 weeks old). The lambs of different sizes were distributed amongst the three tail-length groups. The rates of healing in the lambs of different ages are shown in Table 12. The tail wounds healed fastest in small lambs up to 3 weeks old.

Table 12. Study 5: Experiment 1, Degree of healing of tail wounds 2, 6 and 10 days after marking. (Degree of healing using an eight-point scale in which 8 represented complete healing, 1 no healing and numbers in between equal gradations between complete and no healing). Source: Johnstone 1944

Size of lambs	Degree of healing of tail wounds		
	Times of inspection		
	2 days	6 days	10 days
Large (6-10 weeks old, 65 lambs)	3.7	4.6	6.0
Medium (3-6 weeks old, 142 lambs)	4.0	4.4	6.1
Small (up to 3 weeks old, 35 lambs)	5.0	5.6	7.2

Infection

In Experiment 1 gross infection with pus formation at 6 days after marking was analysed. (This was the time at which the detrimental effects of infection were most noticeable.) Infection was most common in lambs with the tails docked short (96.4% or 54 of 56 lambs with infected tail wounds) and least common in lambs with tails docked long (13.3% or 12 of 89 lambs with infected tail wounds). The rate of infection in lambs with medium tails was in between the rates of infection in lambs with long or short tails (63.9% or 62 of 97 lambs with medium tails).

Infection was also more common in large lambs (51.5% infected) than in small lambs (28.5% infected).

Anatomical factors affecting healing

Factors investigated included the fate of the vertebral remnant if the tail was docked through a vertebra and the level to which muscles extend along the tail. Based on dissection of small number of tails, there was little if any absorption of bone after docking through a vertebra. The results presented in Table 10 indicate that docking the tail through a joint or vertebra did not affect the rate of healing.

Dissection also revealed that muscles extend along the dorsal surface of the tail roughly to about the limit of the bare area on the ventral surface of the tail. When tails are docked long or medium-long little muscle is cut.

Subsequent conformation of the tail stump

In the tails docked long it was possible to leave only a small skin flap at the time of docking. In these lambs the scar was usually located centrally on the tail stump. The shorter the tail, the more commonly was the scar on the on the dorsal surface of the tail; however, these tails were more prone to infection and took longer to heal. The scar was also more commonly on the dorsal surface if the tail had been held straight at docking.

Puckering of the scar from contraction of scar tissue increased as the length of the tail decreased and was very noticeable in short tails. There was also more puckering if a flap of skin was left at docking. Dimples at the dorsal margin of the tail tip were also slightly more common if a flap was left. In Experiment 1, no

dimples occurred in lambs with long tails. Both puckering and dimpling were considered undesirable, with dimple formation thought to predispose to fly strike (Morley and Johnstone 1984).

Conclusions from Study 5

Based on these results, the authors felt confident to conclude the following (Johnstone 1944):

1. "The longer the tail is left at docking the more rapidly the wound heals.
2. Healing takes place at approximately the same rate whether the cut is made through a joint or through a coccygeal bone.
3. The younger the lamb, the more rapid the healing.
4. Healing occurs more rapidly when an excess of skin is left on the tail than when the severed bone protrudes from the wound.
5. Gross infection, retarding healing, develops more frequently in lambs docked at short or medium lengths. It is also more frequent in older and bigger lambs. This appears to be related to the amount of muscle tissue at the site of the incision.
6. The scar is more often formed at the dorsal border of the tail tip, with the consequent freedom of the end of the tail from wool, when the tail is held straight and a flap is obtained by pushing the skin forward with the thumb of the left hand.
7. Undesirable forms of cicatrisation[3], such as dimpling and puckering at the dorsal border of the tail tip, are more frequent among the shorter docked tails, especially when a flap is left."

[3] scarring

Study 6

The aims of this study were to confirm the previous findings using larger numbers of lambs under a variety of conditions and to discover an optimal tail length for general use that would overcome objections to 4-inch (10 cm) tail (Graham and Johnstone 1947a). The earlier studies had demonstrated that the 4-inch tail gave very good protection against fly strike. However, the 4-inch tail was unpopular because it was inclined to stick up or out and was more difficult to shear and crutch (Morley and Johnstone 1984). It was thought that if a tuft of wool was left on the side of a long tail this could become soiled and, in turn, soil the crutch (Joint Blowfly Committee 1943).

The study included 9,135 lambs on five properties in eastern Australia (Table 13). The majority of the lambs were Merino ewe lambs (7,452 of the lambs), plus smaller numbers of Merino wether lambs (583 of the lambs) and Corriedale ewe lambs (1,100 of the lambs).

Table 13. Study 6: Properties and lambs included in the study

Site	Date study commenced	Number of lambs	Age of lambs	Breed and gender
Noondoo near Dirranbandi QLD	June 1943	2,668	2-10 weeks	Merino, female
Gilruth Plains near Cunnamulla QLD	October 1943	1,181	3-8 weeks	Merino, female
Dungalear near Walgett NSW	November 1943	2,922	2-10 weeks	Merino, female
Emu Creek near Walcha NSW	November 1943	1,264	Not provided	Merino, 681 female and 583 male
Jemalong near Forbes NSW	May 1944	1,100	Not provided	Corriedale, female

On each property groups of lambs were docked at lamb marking as follows:

- Long tail – about 3.75 inches (9.4 cm) long or extending half an inch (12.5 mm) below the lower border of the bare area.
- Medium-long tail – just below the tip of the vulva but not extending beyond the lower border of the bare area.
- Medium tail – opposite the vulva orifice but not extending below the tip.
- Short tail – not extending below the upper commissure of the vulva.

On three of the five properties the lambs were mulesed as weaners and only the observations collected between lamb marking and mulesing are discussed here. On the fourth (Emu Creek near Walcha NSW) all the ewe lambs, but not the wether lambs, were mulesed at lamb marking. On the fifth (Jemalong near Forbes NSW) one group of 220 lambs docked with medium-long tails was also treated with the modified mules operation.

On the first property (Noondoo near Dirranbandi QLD) 2,668 ewe lambs were included in the study, run in four paddocks. All the lambs within a paddock were docked to the same tail length. The numbers of lambs in each tail length group were:

- long tails – 678 lambs
- medium-long tails – 825 lambs
- medium tails – 753 lambs
- short tails – 612 lambs.

Lamb marking commenced in June 1943 when the lambs were 2-10 weeks old. The lambs were mustered for shearing approximately 12 weeks after lamb marking and at that time examined for old and active fly strikes. Table 14 summarises the fly strikes observed. After shearing the lambs were mulesed and moved to another property.

Table 14. Study 6: Breech fly strike incidence in unmulesed Merino ewe lambs with varying tail lengths observed approximately 12 weeks after lamb marking, Noondoo. Source: Graham and Johnstone 1947a

Tail length	Number of sheep	% Crutch strikes		% Mixed strikes		% Tail strikes		Total % active	Total % all strikes
		Active	Old	Active	Old	Active	Old		
Long	634	7.9	2.7	0.2	0.2	-	-	8	11
Medium-long	766	15	1.8	0.1	-	-	-	15	17
Medium	673	15.3	13.8	0.3	0.7	0.4	-	16	31
Short	558	16.3	22.7	0.5	1.5	0.9	-	17	42

On the second property (Gilruth Plains near Cunnamulla QLD) 1,181 ewe lambs were included in the study. The lambs were run in four paddocks and within each paddock approximately equal numbers of lambs were docked at the different tail lengths. The numbers of lambs in each tail length group were:

- long tails – 277 lambs
- medium-long tails – 332 lambs
- medium tails – 320 lambs
- short tails – 252 lambs.

Lamb marking commenced in October 1943 when the lambs were 3-8 weeks old. No fly strike data was provided, with the researchers noting that the prolonged severe drought resulted in no fly strikes occurring on this property.

The third property (Dungalear near Walgett NSW) commenced lamb marking in November 1943 when the lambs were 2-10 weeks old. Two thousand, nine hundred and twenty two ewe lambs were included in the study, run in four paddocks. All the lambs within a paddock had their tails docked to the same length. The numbers of lambs in each tail length group were:

- long tails – 559 lambs

- medium-long tails – 801 lambs
- medium tails – 891 lambs
- short tails – 671 lambs.

At five months after marking all the lambs were re-mustered and examined for fly strike. The results of these examinations are shown in Table 15. The lambs were then shorn and mulesed.

Table 15. Study 6: Breech fly strike incidence in unmulesed Merino ewe lambs with varying tail lengths observed approximately 5 months after lamb marking, Dungalear. Source: Graham and Johnstone 1947a

Tail length	Number of sheep	% Crutch strikes		% Mixed strikes		% Tail strikes		Total % active	Total % all strikes
		Active	Old	Active	Old	Active	Old		
Long	528	0.3	5.6	0.2	0.5	-	-	0.7	6.7
Medium-long	783	2.3	9.5	0.5	3.8	0.1	0.1	3.0	16.4
Medium	899	6.1	9.5	0.3	0.4	0.7	0.7	6.8	17.4
Short	601	9.1	18.6	2.9	7.4	1.8	1.8	13.8	41.6

Approximately 7 months after marking the tails of all the sheep in the long-tail group were re-measured: 7% of the animals had tails less than 3.75 inches long, 4% had tails 3.75 inches long, 88% had tails 4-5 inches long and 1% had tails 5.5-7 inches long. The researchers speculated that the increase in tail length in these lambs as they grew was related to the number of coccygeal vertebrae remaining in the docked tail.

On the fourth property (Emu Creek near Walcha NSW) 1,264 lambs were included in the study, 681 ewe lambs and 583 wether lambs. The lambs were run in four paddocks and all the lambs within a paddock had their tails docked to the same length. The numbers of lambs in each tail length group were:

- long tails – 135 ewe lambs, no wether lambs
- medium-long tails – 191 ewe lambs and 187 wether lambs
- medium tails – 207 ewe lambs and 226 wether lambs
- short tails – 154 ewe lambs and 170 wether lambs.

Lamb marking commenced in November 1943. The age of the lambs was not provided; however, their small size was noted and the lambs docked to anatomical reference points rather than to actual measurements. All the ewe lambs were mulesed at lamb marking.

A severe outbreak of fly strike occurred 7-10 days after lamb marking. In the ewe lambs the strikes on the tail and in the mulesing wounds were not reported separately and the researchers commented that there was a high rate of strike within the mulesing wounds. Of the wether lambs, those with medium-long tails experienced the lowest rate of tail strikes (Table 16). No wether lambs had the long tails.

Table 16. Study 6: Tail fly strike incidence in unmulesed Merino wether lambs with varying tail lengths 7 or 14 days after lamb marking, Emu Plains. Source: Graham and Johnstone 1947a

Tail length	Number of lambs in group	% struck 7 days after marking	% struck 14 days after marking	Strikes per 100 lambs for both times
Medium-long	187	0.5	3.7	4
Medium	226	4.3	2.6	7
Short	170	18.8	2.4	21

The fifth property (Jemalong near Forbes NSW) had Corriedale sheep. On this property 1,100 ewe lambs were included in the study, 220 docked with short, medium or long tails and 440 docked with medium-long tails. Lamb marking commenced at the end of May 1944 and the lambs were shorn in July 1944. Half of the lambs with medium-long tails were treated with the modified Mules operation 'off-shears'. Conditions were very dry until late spring. The number of struck sheep was recorded by the property manager; however, the numbers of sheep in each group were not recorded at the same time. Table 17 shows the number of struck sheep and the numbers of sheep in each group in August 1944 and February 1945.

Table 17. Study 6: Breech fly strike incidence in unmulesed and mulesed Corriedale ewe lambs with varying tail lengths, Jemalong. Source: Graham and Johnstone 1947a

Tail length	Number of sheep		Number of sheep stuck	
	August 1944	February 1945	October 1944	November 1945
Long	195	144	2	2
Medium-long, unmulesed	188	134	1	4
Medium-long, mulesed	187	136	0	2
Medium	201	185	10	7
Short	213	186	30	12

At Jemalong, pasture conditions led to faecal dag accumulation when the sheep had about six month's wool (January-February 1945, based on the date of shearing of July 1944). Dag formation increased with increasing tail length, although this was offset by mulesing (Table 18). However, breech fly strike incidence rates in Table 17 suggest that although more unmulesed sheep with medium-long and long tails were daggy compared to the sheep with short and medium tails, this did not seem to make the longer tailed sheep more susceptible to breech fly strike.

Table 18. Study 6: The effect of tail length on dag formation in mulesed and unmulesed Corriedale ewes. Source: Graham and Johnstone 1947a

Tail length	Number of sheep	% no dags	% slightly daggy	% daggy	% very daggy
Long, unmulesed	144	47.7	11	30.9	10.4
Medium-long, unmulesed	136	65.0	13.7	14.7	6.6
Medium-long, mulesed	134	74.8	14.9	5.9	4.4
Medium, unmulesed	185	84.6	11.2	3.7	0.5
Short, unmulesed	186	92.2	2.6	4.7	0.5

At two of the study sites (Gilruth Plains and Dungalear) the degree of urine staining was assessed 5-7 months after marking, before the sheep were mulesed. Results are shown in Table 19. On both properties, docking the tail medium-long resulted in the lowest percentage of sheep classed as stained or very stained. The authors speculated that in the sheep with the medium-long tails the tail pressed the wool around the vulva apart, away from the stream of urine. In the long-tailed sheep the authors noted that in some animals the wool on the ventral surface of the tail was stuck to the crutch by burrs and that these particular sheep were always badly stained.

Table 19. Study 6: The effect of tail length on urine staining in unmulesed Merino ewes. Source: Graham and Johnstone 1947a

Property	Tail length	Number of sheep	% no stain	% slight stain	% stained	% very stained
Gilruth Plains	Long	97	13	44	30	13
	Medium-long	100	12	47	32	9
	Medium	119	9	44	30	17
	Short	114	9	26	38	27
Dungalear	Long	522	9	31	48	12
	Medium-long	783	17	37	39	7
	Medium	899	8	43	37	12
	Short	601	2	33	39	26

Slight stain = staining confined to tip of the wool. Stained = staining extended along the whole length of the wool fibres to the skin surface. Very stained = extensive areas stained down to the skin surface.

On three of the properties at total of 3,070 sheep were examined off-shears to determine the amount of wool left on the tail and crutch. Shearing was most efficient in sheep with medium or medium-long tails. In

sheep with long tails there was a tendency to leave wool on the sides of the tail, and in sheep with short tail on the tail-tip. As tail length increased there was a tendency to leave more wool on the crutch.

Based on the combined results, the authors concluded that docking tails medium-long, so the tip of the tail lay half an inch (12.5 mm) below the tip of the vulva, gave the most satisfactory result. However, they noted the disadvantage of increased dagginess at this tail length in Corriedale lambs and the need to consider this where conditions are conducive to dag formation. They also concluded that there was no merit whatever in very short tails.

Other research on tail length in Australian sheep

In its early descriptions, the Mules operation included cutting the tail short i.e. above the upper commissure of the vulva (Beveridge 1935). Following the observation that it was short tails, not long tails, which were associated with the highest levels of breech fly strike in unmulesed sheep (Gill and Graham 1939; Riches 1941), a similar association was also observed in mulesed sheep (Graham *et al.* 1941). Half the 1940 lamb drop at Gilruth Plains was mulesed at marking in October 1940 and the tails docked either long (4 inches, 10 cm) or short. Conditions were very dry until January 1941, followed by a severe fly wave in autumn 1941. The lambs were crutched in February 1941. The incidence of fly strike in the mulesed ewe lambs with long tails from 1 January – 31 May 1941 was 0.9 strikes per 100 sheep. In contrast, the incidence of fly strike in the mulesed ewe lambs with short tails over the same time period was 8.3 strikes per 100 sheep.

The association between tail length and susceptibility to breech fly strike in mulesed sheep was also observed in the five site field study described in the previous section of the report (Graham and Johnstone 1947a). After mulesing at Noondoo, breech fly strikes were recorded in 16.4% of sheep with short tails, 3.9% of the sheep with medium tails, 1.7% of the sheep with medium-long tails and 2.2% of the sheep with long tails. After mulesing at Dungalear, breech fly strikes were recorded in 31.1% of sheep with short tails, 18.7% of the sheep with medium tails, 8.8% of the sheep with medium-long tails and 11.6% of the sheep with long tails.

The most appropriate tail length for sheep treated with the Mules and tail operations was investigated further in a series of studies after the mid1940s (Moule 1948; Morley 1949; Dun 1954; Watts and Perry 1975; Watts and Marchant 1977; Watts and Luff 1978; Watts *et al.* 1978; Watts *et al.* 1979). In sheep treated with the ordinary Mules plus tail operations, better results were achieved with the medium-long tail than with the short tail, whereas in radically mulesed sheep tail length was reported to have no effect (Dun 1954). However, research reported during the 1970s found that docking the tail medium-long was the most appropriate length for sheep mulesed with either the modified (Watts and Marchant 1977; Watts *et al.* 1978) or radical Mules operations (Watts and Perry 1975; Watts and Luff 1978). Docking the tail of mulesed sheep short (above the upper commissure of the vulva) did not provide substantial protection against fly strike (Moule 1948; Morley *et al.* 1976; Watts and Marchant 1977; Watts and Luff 1978).

The studies in unmulesed sheep described in the previous section were mainly conducted under rangeland conditions in low dag environments in Queensland and New South Wales and before the establishment of improved pastures in the cooler, higher rainfall regions of Australia. Prior to the introduction of improved pastures the main type of fly strike in unmulesed sheep was crutch strike associated with urine staining (Watts and Perry 1975). Pasture improvements in cooler, higher rainfall regions of Australia since 1945 have resulted in increased sheep numbers held under increased stocking rates, and have been associated with higher rates of scouring (Watts and Marchant 1977). In scouring sheep with short tails the tail wool tends to drop down over the anus and become wetted with faecal material predisposing to tail strike, with this disadvantage of short tails observed in both mulesed and unmulesed sheep (Watts and Perry 1975). The increased susceptibility to fly strike of scouring sheep with short tails has been observed in both mulesed and unmulesed animals (Watts and Perry 1975; Morley *et al.* 1976; Watts and Marchant 1977; Watts and Luff 1978;).

Despite these findings, a survey of 40 graziers on the central, north-eastern and north-western plains and southern tablelands and south-western slopes of NSW during the 1970s revealed that the most graziers docked theirs lambs' tails level with the buttocks ('butted') or at the first joint palpable on the underside of

the tail (Watts *et al.* 1979). The reasons given for this were that the sheep were easier to crutch, less likely to be soiled with faeces, and for prime lambs, that the body condition was then more obvious, encouraging a better market price. However, the tails of lambs butted or docked short took approximately 2 weeks longer to heal (5-6 weeks) and were more susceptible to fly strike, which is no surprise given the earlier research discussed previously. In plain ewes, such as crossbreds or British breeds, the greatest factor predisposing to fly strike was a short or butted tail (10.1% of 1,085 sheep struck) and correct tail length alone usually gave adequate breech strike control (1.8% of 451 sheep struck).

Discussion

Review of the literature revealed six studies conducted during the 1930s and 1940s that investigated the most appropriate tail length for unmulesed Merino sheep, with these studies conducted prior to the description of surgical operations to control tail strike (i.e. tail stripping). The studies included more than 10,000 sheep on five properties in eastern Australia and clearly demonstrated that docking the tails of unmulesed Merino sheep either medium-long (extending to just below the tip of the vulva in ewes and an equivalent length in wethers) or long (at the fourth joint or to give a 3.75-4 inch/9.4-10 cm tail that extended just below the lower border of the natural bare area) gave better protection against breech fly strike than docking to give a medium length (2 inches/5 cm long or tip opposite the vulva orifice) or short (tail tip not extending below the top of the vulva) tail (Figure 2). Leaving the tail undocked also provided better protection against breech fly strike than docking to give a medium length or short tail.

The evidence to support the contention that, when docked to the same length, mulesed sheep tend to have a shorter tail than unmulesed sheep was not compelling. Regardless, this review has revealed that a long tail in unmulesed sheep actually gave the best protection against breech fly strike, but was rejected for other reasons, i.e. it was inclined to stick up or out and was more difficult to shear or crutch. If shorn or crutched carefully, a long tail may not provide a disadvantage in terms of protection against breech fly strike.

Docking the tails of unmulesed Merino at the second joint or shorter resulted in an inferior result, with these sheep experiencing two to three times the rate of breech fly strike as sheep with the tails docked long or medium-long. Dissection of the tails of a limited number of lambs revealed that muscles extend along the dorsal surface of the tail approximately to the limit of the bare area on the ventral surface of the tail. When tails are cut to a short or medium length it is likely that these tail muscles are cut, resulting in sheep with a restricted range of tail movements.

Short and medium length tails took longer to heal than medium-long or long tails and were more likely to be infected. Healing was also prolonged in older lambs, with higher rates of infection. Healing following different methods of tail docking (cold knife, rings, hot/gas docking knife) was not part of this review. Apart from healing and risk of infection, the acute welfare impact of docking of the different tail lengths was also not addressed.

One issue that was not conclusively resolved during this early research was the relationship between tail length in unmulesed sheep and dag formation. The studies were largely conducted in low-dag environments and, because of the time when these studies were conducted, the highly improved pastures that can lead to dag formation were not in existence. One of the studies suggested that wethers with long tails were less susceptible to dag formation than wethers with short tails; however, numbers were considered too small to provide conclusive evidence (Riches 1942). In another, dag formation increased as tail length increased, but the sheep with medium-long or long tails were still less susceptible to fly strike than those with short and medium length tails (Graham and Johnstone 1947a). Subsequent research in the 1970s revealed that scouring, unmulesed sheep with short tails are susceptible to breech fly strike. Because animals with short tails most likely have a restricted range of tail movements they are probably unable to fully lift their tails when they defecate. During shearing there is a tendency to leave wool on the tail-tip of short-tailed sheep. This wool hangs down over the anus and become wetted with faecal material predisposing to tail strike. Ewes with short or medium-length tails are also unlikely to be able to fully lift their tails when they urinate. With long or medium-long tails little muscle is cut.

Recent research with the Te Pari Patesco knife in unmulesed sheep in Western Australia has indicated that the length of the bare area on the tail tip has an influence on dag accumulation (Smith *et al.* 2012). Research

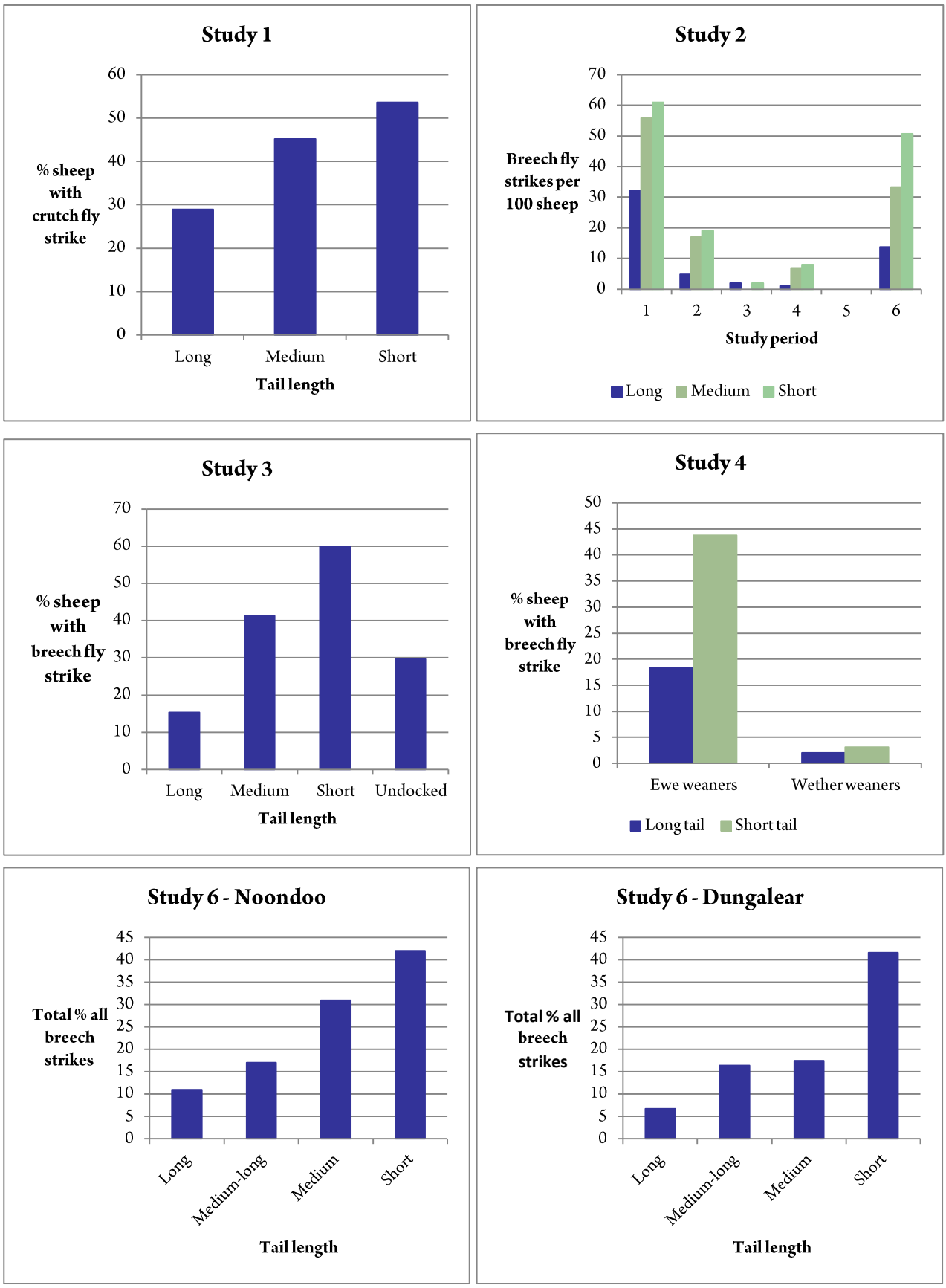
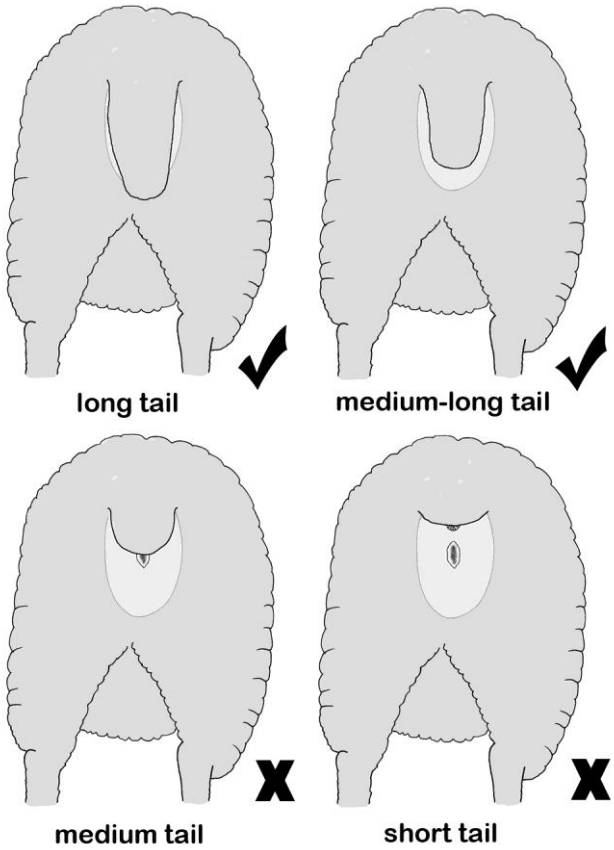


Figure 2. Summary of results of research conducted in the 1930s and 1940s on the influence of tail length on susceptibility to breech fly strike in unmulesed sheep. (For study 2 refer to Table 4 for a description of the study periods.)

in the 1940s indicated that, when docking with a cold knife, it is possible to leave only a small flap of skin in tail docked long, with the scar subsequently located centrally on the tail stump (Johnstone 1944). In contrast, in shorter tails the scar was more commonly on the dorsal surface of the tail (Johnstone 1944). The length of the bare area on the tail tip may be confounding the association between of tail length and dag formation in unmulesed sheep.

There is no doubt that tail docking is painful. To optimise the lifelong animal welfare benefit it provides for sheep in terms of protection from breech fly strike it should be done in a way that minimizes short term suffering and maximizes long term benefit. In this regard, the findings of the early research on tail length in unmulesed sheep and the recommendations based on this research provided by the Joint Blowfly Committee in 1943 are as relevant today as when first published:

- "When docking lambs, the aim must be to cut the tail at the level that will bring the tip about ¼ to ½ inch below the tip of the vulva. As the lamb grows this relationship of tail-tip to vulva-tip will be closely maintained…
- Docking is an important operation, and none but careful workers should be allowed to do it…
- Under no circumstances should the cut be made below the bare skin on the under surface of the tail…
- The younger the lamb docked, and the longer the stump left, the more quickly the wound heals…
- When lambs are docked short a considerably larger wound results, healing is delayed, and the wound is much more likely to become infected. It is under these circumstances that the tails of recently docked lambs are most likely to become struck. There is this further advantage, therefore, in the longer tail."



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Joan Lloyd Consulting Pty Ltd
ACN 129 442 431

Address
PO Box 496
West Ryde NSW 1685

Web
joanlloydconsulting.com.au

Telephone
(02) 9874 8637

Facsimile
(02) 9874 3035