Reference Point

Evaluation of the scientific justification for tail docking in dairy cattle

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The practice of tail docking of dairy cows appears to have originated in New Zealand and by the 1990s was a common procedure in that country.[1] A variety of benefits have been attributed to tail docking, including improved comfort for milking personnel and enhanced udder and milk hygiene.[1] Although the practice has been increasing in US dairy herds, its reported benefits have been questioned by researchers who raise concerns related to animal welfare and efficacy.[2] In a survey[3] conducted in New Zealand, tail docking was viewed as a welfare concern by 60% of the general public and, interestingly, 53% of nondairy farmers. It is likely that US consumers will have similar concerns. In the United States, the issue ultimately may be resolved through trade negotiations or legislation. Veterinarians will need to address these issues in their practices and when developing position statements for various professional associations. It is likely that veterinarians will be key advisors in deliberations within the dairy industry and a credible source of information for consumers.

Our working hypothesis for this review was that there is no benefit to tail docking of dairy cattle. Lay publications were evaluated to determine the alleged purpose and management factors associated with the practice of tail docking in the dairy industry. Computer-assisted databases (MEDLINE, BIOSIS, and AGRICOLA) were used to identify the peer-reviewed scientific literature available. Governmental and regulatory reports from a variety of countries also were collected and reviewed.

Regulatory Policies

National animal welfare policies and regulations are developed in response to scientific discovery or consumer and political opinion. The variation between such policies and regulations may reflect differences in social ethics, economics, or consumer perception. Regulatory policies specific to tail docking dairy cattle vary considerably from country to country, and the regulatory oversight of established policies and guidelines is highly variable among countries. Tail docking is prohibited in Denmark, Germany, Scotland, Sweden, and the United Kingdom. Some Australian states prohibit the procedure, but where it is permissible, docking should only be performed when recommended by a veterinarian for udder health reasons. Additionally, Australian guidelines recommend that cattle be < 6 months of age when the procedure is performed and that local anesthesia is used between 3 and 6 months of age. Australian producers must leave the stump long enough to cover the vulva. In New Zealand, a veterinarian must perform tail docking by application of a rubber ring. Canadian guidelines recommend that competent personnel with proper equipment conduct the procedure on calves at a young age and that precautions are taken to control unnecessary pain. The position statement of the Canadian Veterinary Medical Association officially opposes tail docking of dairy cattle as a routine management practice.

In the United States, there are no federal or state laws or regulations regarding tail docking of cattle. However, throughout the United States, there has been an increase in the development and implementation of quality assurance programs for agricultural animals. In the dairy industry, the focus has been on food safety, environmental stewardship, and animal health. Some dairy producers have chosen to participate in certification programs, which assure consumers that dairy products were produced under certain minimum welfare standards. Presently, there exists 1 voluntary on-farm certification program for dairy producers with welfare standards for the care and handling of dairy animals, and it includes no tail docking as 1 of its standards.[4]

The recent discussion of the Organization of International Epizootics to consider animal welfare in trade standards is an interesting development. In the future, animal welfare standards may be recognized as nontariff barriers to trade. An appreciation of the published science regarding the impact of a given animal management procedure on an animal is only the baseline necessary for policy development and trade standard negotiations. Public perception will also play a role. Countries with established national standards will be at a bargaining advantage. Ideally, US animal commodity groups are taking notice of these events and are preparing for the possibility that the United States may

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be asked in the near future to trade according to published national animal welfare standards.

Functions of the Tail

The tail may play a primary physiologic or behavioral role or may be integrated with mechanisms to contribute to a systemic function. For example, the tail of a calf may dissipate surplus heat by vasodilation and by elevating the tail away from the body. However, other parts of the circulatory system may also contribute to reducing the heat load during thermal stress. During cold stress, vasoconstriction occurs, and the tail is positioned closer to the body to conserve heat.[5,6]

The tail functions as a visual form of communication between herd mates and is also recognized as a communication tool by caretakers. The mood or activity of a cow may be ascertained by the position of the tail and other head, ear, or postural changes.[7] During normal activities such as grazing, standing, or walking, the tail hangs downward in a relaxed position against the pelvic bones. When the cow becomes frightened or submissive, the tail becomes drawn towards the body between the rear limbs. A cow in estrus will often display an elevated and curled tail position. When a cow increases ambulation from a walk to gallop, the tail increases in elevation.[8] Aggression and fighting will also cause the tail to elevate, but this may be attributable to the initiation of locomotion. Conflict, pain, and frustration are associated with tail wagging or flicking movements of the tail and may be a signal of the intent to kick. Cutaneous irritation by biting insects can evoke lateral movements of the tail in a swishing or flicking motion.[1,9] These normal functions of the tail have advantages for cows and their caretakers, and the natural benefits of having a tail may be lost with its removal.

Methods of Tail Docking

A wide variety of tail docking methods have been described. The most common docking method reported in the literature is amputation by rubber band constriction.[a] Among the 35% of Australian dairy producers who reported that they docked tails, rubber bands were used by 75%.[10] The banded tail becomes necrotic and detaches between 3 and 7 weeks after banding.[11-13] In adult cattle, the necrotic tail is frequently severed manually 7 or more days after banding to prevent the tail from clogging the facility's waste management system.[2]

Placement of the rubber band may affect the amount of subsequent tail inflammation. In a study[14] involving 3 sets of twins, tail swelling and radiographic evidence of bone and soft tissue inflammation at the banding site were more severe when the band was applied over the vertebra rather than over the joint. Clostridial disease (including gangrene and tetanus) that developed after docking has been reported, leading to the practice of prophylactic clostridial vaccination prior to docking.[11,12]

Variation exists in the age chosen for tail docking. In Australia, mean age at banding was 18 months, with a range of 1 to 43 months.[10] Producers in the United States frequently dock heifers approximately 1 month prior to calving to avoid potential reduction in milk production.[2,12] Some producers choose to dock young heifers at or near weaning.[b]

There is also variation in the amount of tail removed. Typically, between one third and two thirds of the tail is removed. The Australian survey[10] reported that 54% of responding producers dock to the level of the udder attachment. The remaining producers were evenly split, with half docking above and half docking below that point. New Zealand's Animal Protection Regulations adopted in 1972 require that tails be docked not < 5 cm below the ventral tip of the vulva in a cow and not < 2.5 cm below the tip of the vulva in a calf.[11]

It has been suggested that when the tail is banded too close to its attachment, vertebral processes protect the tail's arteries from constriction and interfere with docking.[11] These authors recommended that the band be placed distal to the sixth coccygeal vertebrae. One author suggested that docking too close to the base will not leave enough tail for tail restraint and may also allow the tail stump to part the vaginal lips, permitting contamination with manure.[15] In anecdotal reports[11] it is also advised that leaving the stump of the tail too long can rub the udder, causing sores. An uncommon practice is for dairy producers to amputate only the portion of the tail covered by the switch.[3,11]

Alternative docking procedures have been advocated or tested experimentally. In 1 study[13] involving 3- to 4-month-old calves, docking by banding was compared with amputation by use of a hot docking iron (a heated scissors-like tool commonly used to sever the tails of lambs) with or without local anesthetic. There was no significant difference in cortisol response among treatment groups and nondocked calves, but hemorrhage was a problem in some calves docked with the docking iron. Amputation by use of emasculator has been reported in beef[16] and dairy calves.[10] On the basis of an experiment in mice,[17] Gregory and Matthews[11] suggested that dipping the tail in liquid nitrogen might be a less painful method of tail docking in cattle.[5]

Tail Management Alternatives to Docking

A common alternative to tail docking in dairy cows is switch trimming. In Australia, 60% of the surveyed producers trimmed tail switches a mean of 1.6 times/y (range, 1 to 6 times/y).[10] In New Zealand, producers that did not dock believed they could adequately maintain cleanliness by switch trimming 2 to 3 times/y.[3] In a study[9] comparing banding, switch trimming, and no treatment, the proportion of flies on the rear quarters of trimmed cows was intermediate between that of cows with complete and docked tails. The authors suggested that a compromise between milking personnel's comfort might be achieved by trimming the switch in the spring (when the tail was more likely to be dirty) and allowing it to grow back over the summer (when fly numbers are highest).

Congenital lack of a tail has been reported in a number of cattle breeds and is estimated to occur in every 3,000 to 20,500 births.[18] The condition is potentially hereditary in Holsteins, but it would be unwise to select for a trait associated with defects including malformations of the spine and displaced anus.

Welfare Considerations of Tail Docking

Duncan[19] suggested that there are welfare benefits and costs to an individual animal associated with elective surgeries such as castration, dehorning, or tail docking. The short-term welfare costs must be weighed against the long-term welfare benefits. For example, the welfare cost of docking may include chronic or acute pain and increased fly predation, whereas the long-term benefits may be improved udder cleanliness and health. Identification of the costs and benefits will assist in justifying the management practice of docking.

Acute Pain and Discomfort

Experimental measurement of pain and discomfort in animals is difficult to perform with accuracy. Several published studies have attempted to evaluate pain resulting from tail docking by use of a variety of physiologic indices and behavioral assessments. In a study[b] involving 3- to 5-week-old calves, sensitivity of the tail to heat was absent by 60 to 120 minutes after banding. Banded calves were significantly more active than controls were during that period. In another study[14] involving 15 sets of twin cows banded prior to calving, the cows continued to graze "apparently unconcerned" immediately after banding. At 6 hours after banding, cortisol concentrations were increased, and cows had increased tail movements, but by 24 hours blood cortisol concentrations had returned to baseline concentrations, and the cows had less tail movement. Although no overt signs of pain or discomfort were observed in these cows after banding, the author did report that signs of pain were occasionally observed in cows that were routinely docked at the research facility.

Pain relief by use of local anesthesia has been evaluated in controlled studies. Ten of fifteen 3- to 4-month-old calves had signs of discomfort (restlessness, tail shaking, or vocalization) for up to 1 hour after banding procedures.[20] Seven of 15 calves that received an injection of lidocaine epidurally prior to banding had similar behavior, but the behavior was delayed approximately 2 hours. Standing, walking, grazing, and ruminating behaviors were not affected by docking. In a similar study[13] by the same authors, cortisol responses in most calves docked by either banding or docking iron were not significantly different from those of control calves. In addition, the cortisol responses did not support using 1 method over the other when local anesthesia was used.

A lidocaine ring block also had no benefit in heifers banded 1 month prior to parturition.[2] In that study, significant detectable changes in lying, standing, walking, drinking, head-to-tail, or grooming behaviors were not found between groups before or after banding or before or after docking. Feed consumption increased slightly but significantly ($P < 0.01$) in docked cows, which the authors speculated might be a displacement behavior. Cortisol concentrations were generally greater in the control group over time than in the banded or banded plus ring block groups. In lactating cows, no significant differences in milk production or feed intake were observed between cows banded with and without epidural analgesia and control cows.[c] No significant differences were found in most behaviors, with the exception of a decrease in frequency of tail shaking in banded cows.

Collectively, results of these studies suggest that tail docking by banding causes, at most, mild discomfort of limited duration and that there is little or no apparent benefit gained through the use of local anesthesia.

Chronic Pain

Chronic pain after docking procedures is an important factor for consideration. Self-mutilation has been reported in dogs that have undergone tail docking.[21] Signs of neuropathic pain have been observed in animals after experimentally induced nerve trauma.[22] This is potentially analogous to phantom limb pain that is reported in approximately three fourths of human amputees.[23,24] The cause of phantom limb pain has not been fully elucidated and may in fact have a multifactorial etiology.

One potential cause of chronic pain is formation of a neuroma, a disorganized bundle of nerve fibers produced in response to nerve damage. Amputation neuromas have been identified in lambs, pigs, chickens, and dogs,[21,25-27] and there is at least 1 anecdotal report[2] of neuromas developing in cattle after tail docking. The question of whether tail docking cattle results in chronic pain remains unresolved.

Fly Avoidance Behavior

Another potential welfare issue of tail docking is reduction in the ability of the cow to remove flies.[28] High rates of tail flicking occur with high fly populations, and tail flicking is an effective deterrent against biting insects on the caudal portions of the body of cattle.[1] Even at high fly densities, the tail is almost completely effective at eliminating fly predation.[1,29]

Tail movement is not the only behavior used in responding to irritating insects. Matthews et al[9] listed 6 behaviors used in observational studies and collectively called total fly avoidance behavior. These included tail flicking, shoulder skin rippling, front leg stamping, rear leg stamping, and head turning to the front or rear half of the body. The avoidance behavior that is initiated appears to be related to the location of insect irritation, whether on the cranial or caudal half of the body.

Several studies have examined fly avoidance behavior in docked cattle. One cow from each of 5 sets of identical twins was docked in a study[1] comparing the behaviors of cows with complete and docked tails in response to varying fly numbers in a pasture environment. At low fly numbers, no significant difference was observed between the 2 groups in the frequencies of front or rear fly avoidance behaviors. At high fly populations, no significant difference was observed in the front fly avoidance behaviors, but docked cows performed significantly more rear-focused avoidance behaviors than cows with complete tails did. In addition, more flies were evident on the caudal portions of the body of the docked cows, compared with nondocked cows. However, there was no significant difference between docked and nondocked cows in plasma cortisol response to an ACTH challenge. These authors suggest that behavior is a more sensitive measure of fly predation than results of an ACTH challenge. More recent studies[28,29] also found that docked cows had greater numbers of flies on the hind limbs and overall and that there were no differences in measured physiologic stress indicators between docked and nondocked cows.

Fly avoidance behaviors of lactating cows in paddocks have also been evaluated in an extensive 10-month study in New Zealand. Fifty-six pregnant heifers were assigned to 3 treatment groups: docked, nondocked, and tail-switch trimmed.[9] There was no significant difference in the amount of front fly avoidance behaviors (shoulder skin rippling, forelimb stamping, or head turning) among the 3 treatment groups. Total fly avoidance behavior and rear avoidance behavior (tail flicks and rear limb stamping) were significantly more frequent in docked cows than in cows with complete tails. Cows with trimmed switches had significantly greater fly avoidance behaviors than cows with complete tails. During high fly periods, the proportion of the flies on the caudal portions of the body was highest for the docked cows, intermediate for the switch-trimmed cows, and lowest for the nondocked cows ($P < 0.05$). The proportion of flies that settled on the caudal portions of the cow increased as the tail length decreased. Cortisol concentration in milk was measured as a stress indicator, and no significant difference was detected among treatment groups. The alternative fly avoidance behavior (limb stamping) was ineffective at removing flies. The results suggested that fly avoidance behavior is compromised by switch trimming but not as severely as by tail docking, which prevents normal fly avoidance behavior and is detrimental to the cow's welfare.

Animal and Public Health Considerations of Tail Docking

Cleanliness and udder health—A variety of benefits have been attributed to tail docking, including improved cow cleanliness, udder health, milk hygiene, and milk production. Proponents of tail docking maintain that docked cows remain cleaner because a tail is not present to spread manure on the udder and the caudal portions of the body. This view is supported by anecdotal reports.[11,30] A recent study[31] examined the effect of docking on cow cleanliness. Docked (n = 223) and nondocked (190) cows housed in free stalls were enrolled in an 8-week study. No significant treatment differences were found in 4 measures of cow cleanliness, 2 measures of udder cleanliness, or udder health (somatic cell count). Udder cleanliness was scored in the parlor during evening milkings on weeks 2 and 4 after docking. The authors noted that tail docking did not provide cleanliness or udder health benefits to the dairy cattle in that study. The authors concluded that given the disadvantages of docking and lack of cleanliness or udder health benefits from tail docking, they could see no merit in adopting the procedure.

Additional limited information is available from several non–peer-reviewed sources and abstracts. No significant differences between milk yield, somatic cell counts, or frequency of mastitis were found among 2-year-old dairy heifers with docked (n = 18), switch-trimmed (19), or complete tails (19) that were kept on pasture and milked in a rotary parlor.[9] That study also found no difference between frequencies of having to rewash the udder before attaching the milking machine. Cows were observed during 1 lactation, and the authors acknowledge that the small sample size resulted in low statistical power and limited their ability to detect differences that may have existed among study groups.

Information presented at a New Zealand farmers' conference reported on 15 sets of identical twin cattle in which 1 twin was docked and the other was not docked.[14] The cows were observed during a complete lactation, and no difference in total milk production was detected between the 2 groups. Cows with docked tails were significantly cleaner in the area immediately adjacent to the base of the tail, but all other areas (including the udder) were not significantly cleaner in the docked cows. In a more recent US study,[29] it was also reported that the caudal portions of the bodies of docked cows were significantly cleaner (3.4 vs 2.4 on a 5-point scale) than those of nondocked cows were. However, the udders of docked cows were not significantly cleaner than those of nondocked cows.

A Japanese study[32] examined the patterns of paint deposition on the bodies and udders of cows after application of water-based paint to their tails or hind limbs. That study was done on a small number of cows and not subjected to statistical analysis or peer review. The paint was applied to simulate dirt or manure that accumulates on the cow. Painted complete tails deposited the paint around the caudal portions of the body and flanks of the cows and on the udders. It was also observed that the higher the paint was applied on the limbs, the more paint ended up on the body and udder as the result of limb movements and lying postures. These results suggest that hygiene (ie, lack of manure deposition on the tails and limbs) will result in cleaner cows and that the limbs of the cow rather than the tail are more likely to soil the udder.

There have been no controlled studies comparing different free-stall designs and different methods or timing of free-stall alley cleaning. Additional studies designed with appropriate statistical power conducted on dairies more typical of the US dairy industry are needed to unequivocally answer the question of whether the practice of tail docking impacts cow cleanliness.

Parlor design and milker comfort—Milkers who attach milking units from behind the cow through the hind limbs (in parallel or rotary parlors) potentially have more difficulties with dirty tails than those on dairies where the cows are milked from the side (herringbone or side-opening parlors). In the New Zealand study[9] involving docked, complete, and switch-trimmed tails of 2-year-old heifers milked from the rear in a rotary parlor, the researchers observed few instances of tails contacting the milkers. Contact of the tail with the milker's arms that was initiated by the cow occurred less than once for every 10 cow milkings. During the experiment, switch-trimmed or complete tails contacted milker's faces approximately once every 1,000 to 1,500 individual cow milkings. Complete tails were moved by milkers away from the cups or to the side during milking more often than were tails with trimmed switches.

Parallel-designed parlors are becoming more common in the United States because of the advantage in the increased number of cows milked per hour. The authors of a recent publication on parallel parlor design and performance note that a major disadvantage to such a milking parlor design is interference with milking by the tail because the cows are milked through the hind limbs rather than from the side.[33] The authors note, however, that a correctly designed butt plate will allow the cows to place their tails on the top of the plate where the tails will not interfere with milking or be lying in manure and urine. We conclude from these authors that proper design of equipment will make tail docking unnecessary.

Risk of leptospirosis for milking personnel—Tail docking has been cited as a useful measure in preventing leptospirosis in dairy workers. Comprehensive reviews[34-37] of the public health aspects of leptospirosis are available. Leptospirosis is endemic in cattle herds of the United States. In a national abattoir survey[38] involving 49 states and Puerto Rico, leptospires were isolated from 1.7% of 5,142 adult bovine kidney samples. Leptospires' ability to penetrate abraded skin and intact mucous membranes can lead to infections in humans who have routine contact with cow urine. Historically this association has been so strong that in some countries the disease was referred to as dairy farm fever and milker's fever.[39,40]

Approximately 50 to 100 human leptospirosis cases were reported annually in the United States from 1967 to 1995 (when mandatory notification for the disease ceased), but the source of these infections was not indicated.[41] Although this almost certainly represents only a fraction of the actual number of cases, which could be more than 5 times the reported number,[42] the actual number of cases probably remains low.

In view of the potential role that cow urine plays in human infection, it was speculated that a urine-soaked tail hitting a milker's face represented a substantial health risk. In a pivotal study,[43] it was found that milkers' leptospiral titers were not related to tail docking. A possible conclusion from that study is that there is adequate exposure to cow urine in endemically infected herds to cause human infection regardless of the presence or absence of tails.

There is evidence that vaccination reduces or even prevents the excretion of leptospires in urine.[44] As the result of a national cattle vaccination program, New Zealand was able to reduce reported annual human leptospirosis cases from almost 700 in 1979 to approximately 100/y.[45] Vaccination of dairy cattle remains the most important precaution in the prevention of leptospirosis in dairy workers. Commercial pentavalent leptospiral vaccines are available.[46] A variety of revaccination intervals ranging from 3 to 12 months have been proposed for dairy cattle.[46]

Conclusions

A review of the available literature suggests that the tail docking procedure causes minimal and transient acute discomfort to cattle. The role of chronic pain remains unknown. In facilities with high fly densities, docked cattle have significantly greater fly predation than nondocked cattle. Because most dairies have high fly densities, especially during the warm months, tail docking is detrimental to the cow's welfare and comfort. Proponents of tail docking believe that the practice is beneficial to the farm personnel and to the cows; however, available data do not support claims that docking improves the dairy worker's comfort or safety or the health or cleanliness of the cow's udder. Switch trimming may provide a compromise for milking personnel's comfort and fly avoidance behavior of the cow.

On the basis of the available peer-reviewed studies and governmental sponsored research, we conclude that there is ample evidence to support our working hypothesis that there is no benefit to tail docking in dairy cattle. Presently, there are no apparent animal health, welfare, or human health justifications to support this practice. Until evidence emerges that tail docking has benefits to animal well-being, health, or public health, the routine practice of tail docking should be discouraged.

[a]Elastrator, NASCO, Fort Atkinson, Wis.
[b]Eicher SD, Morrow-Tesch JL. Tail-docking alters behavior but not acute phase proteins of young dairy calves (abstr), in *Proceedings*. Am Soc Anim Sci 1999;9.
[c]Tom EM, Duncan IJH, Widowski TM, et al. Does tail docking adversely affect adult dairy cattle (abstr)?, in *Proceedings*. Int Congr Int Soc Appl Ethology 2000;34:203.

References

1. Phipps AM, Matthews LR, Verkerk GA. Tail docked dairy cattle: fly induced behaviour and adrenal responsiveness to ACTH, in *Proceedings*. N Z Soc Anim Prod 1995;55:61–63.
2. Eicher SD, Morrow-Tesch JL, Albright JL, et al. Tail-docking influences on behavioral, immunological, and endocrine responses in dairy heifers. *J Dairy Sci* 2000;83:1456–1462.
3. Loveridge A, Bagshaw C, Matthews L. *Taildocking of cattle: adoption of alternative practices*. Wellington, New Zealand: Ministry of Agriculture and Fisheries, 1996;1–35.
4. American Humane Association. *Welfare standards for dairy cows*. Washington, DC: Farm Animal Services, 2002.
5. Wittow GC. The significance of the extremities of the ox (*Bos taurus*) in thermoregulation. *J Agric Sci* 1962;58:109–120.
6. Walls JR, Jacobson DR. Skin temperature and blood flow in the tail of dairy heifers administered extracts of toxic tall fescue. *J Anim Sci* 1970;30:420–423.
7. Albright JL, Arave CW. *The behaviour of cattle*. 1st ed. New York: CAB International, 1997;45–49.
8. Kiley-Worthington M. The tail movements of ungulates, canids, and felids with particular reference to their causation and function as displays. *Behavior* 1976;106:69–115.
9. Matthews LR, Phipps A, Verkerk GA, et al. *The effects of tail-docking and trimming on milker comfort and dairy cattle health, welfare and production*. Hamilton, New Zealand: Animal Behavior and Welfare Research Centre, 1995;1–25.
10. Barnett JL, Coleman GJ, Hemsworth PH, et al. Tail docking and beliefs about the practice in the Victorian dairy industry. *Aust Vet J* 1999;77:742–747.
11. Gregory N, Matthews L. *Tail docking of dairy cattle*. Wellington, New Zealand: Ministry of Agriculture and Fisheries, 1998;1–61.

12. Kirk JH. Tips on tail trimming. *The Western Dairyman* 1999;Apr:40–41.

13. Petrie NJ, Mellor DJ, Stafford KJ, et al. Cortisol responses of calves to two methods of tail docking used with or without local anaesthetic. *N Z Vet J* 1996;44:4–8.

14. Wilson GDA. Docking cow's tails, in *Proceedings*. Ruakura Farm Conf 1972;158–166.

15. Jaquish N. Tail docking means cleaner cows, lower cell counts. *Hoard's Dairyman* 1991;25:708.

16. Shakalov KI, Kuznetsov GS, Semenov BS, et al. Traumatic paraplegia in fattening bulls (resulting from tail injury, and its prevention by docking). *Veterinariya (Moscow)* 1975;10:94.

17. Morgret MK. A simple tail removal procedure for studying the role of tail rattle in mouse aggression. *Behav Res Methods Instrum* 1972;4:224.

18. Huston K, Wearden S. Congenital taillessness in cattle. *J Dairy Sci* 1958;41:1359–1370.

19. Duncan IJH. Practices of concern. *J Am Vet Med Assoc* 1994;204:379–384.

20. Petrie NJ, Stafford KJ, Mellor DJ, et al. The behaviour of calves tail docked with a rubber ring used with or without local anaesthesia, in *Proceedings*. N Z Soc Anim Prod 1995;55:58–60.

21. Gross TL, Carr SH. Amputation neuroma of docked tails in dogs. *Vet Pathol* 1990;27:62–67.

22. Bennett GJ, Xie YK. A peripheral mononeuropathy in rat that produces disorders of pain sensation like those seen in man. *Pain* 1988;33:87–107.

23. Jensen TS, Krebs B, Nielsen J, et al. Phantom limb, phantom pain and stump pain in amputees during the first six months following limb amputation. *Pain* 1983;17:243–256.

24. Sherman RA, Sherman CJ, Parker L. Chronic phantom and stump pain among American veterans: results of a survey. *Pain* 1984;18:83–95.

25. French NP, Morgan KL. Neuromata in docked lambs tails. *Res Vet Sci* 1992;52:389–390.

26. Simonsen HB, Klinken L, Bindseil E. Histopathology of intact and docked pigtails. *Br Vet J* 2001;147:407–412.

27. Gentle MJ. Neuroma formation after partial beak amputation (beak trimming) in the chicken. *Res Vet Sci* 1986;41:383–385.

28. Ladewig J, Matthews LR. The importance of physiological measurements in farm animal stress research, in *Proceedings*. N Z Soc Anim Prod 1992;52:77–79.

29. Eicher SD, Morrow-Tesch JL, Albright JL, et al. Tail-docking alters fly numbers, fly avoidance behaviors, and cleanliness, but not physiological measures. *J Dairy Sci* 2001;84:1822–1828.

30. Prevent injury and infections by docking two-thirds of the tail. *Hoard's Dairyman* 1998;Oct 25:716.

31. Tucker CB, Fraser D, Weary DM. Tail docking dairy cattle: effects on cow cleanliness and udder health. *J Dairy Sci* 2001;84:84–87.

32. Abe N. The deeper the "mud," the dirtier the udder. *Hoard's Dairyman* 1999;144:439.

33. Smith JF, Armstrong DV, Gamroth MJ, et al. *Parallel milking parlor performance and design considerations (guide D 102)*. Las Cruces, NM: New Mexico State University, 1991;1–6.

34. Hanson LE. Leptospirosis in domestic animals: the public health perspective. *J Am Vet Med Assoc* 1982;181:1505–1509.

35. Songer JG, Thiermann AB. Zoonosis update: leptospirosis. *J Am Vet Med Assoc* 1988;193:1250–1254.

36. Heath SE, Johnson R. Leptospirosis. *J Am Vet Med Assoc* 1994;205:1518–1523.

37. Ellis WA. Leptospirosis as a cause of reproductive failure. *Vet Clin North Am Food Anim Pract* 1994;10:463–478.

38. Miller DA, Wilson MA, Beran GW. Survey to estimate prevalence of *Leptospira interrogans* infection in mature cattle in the United States. *Am J Vet Res* 1991;52:1761–1765.

39. Christmas BW, Bragger JM, Till DG. Dairy farm fever in New Zealand: isolation of *L pomona* and *L hardjo* from a local outbreak. *N Z Med J* 1974;79:904–906.

40. Huitema SW, Pal TM, Groothoff JW. Milker's fever, an occupational disease on the increase. *Ned Tijdschr Geneeskd* 1989;133:1939–1941.

41. Groseclose SL, Knowles CM, Hall PA. Summary of notafiable diseases, United States, 1998. *MMWR CDC Morb Mortal Wkly Rep* 1999;47:1–93.

42. Farr RW. Leptospirosis. *Clin Infect Dis* 1995;21:1–6.

43. Mackintosh CG, Schollum LM, Blackmore DK, et al. Epidemiology of leptospirosis in dairy farm workers in the Manawatu. Part II: a case-control study of high and low risk farms. *N Z Vet J* 1982; 30:73–76.

44. Bolin CA, Thiermann AB, Handsaker AL, et al. Effect of vaccination with a pentavalent leptospiral vaccine on *Leptospira interrogans* serovar *hardjo* type hardjo-bovis infection of pregnant cattle. *Am J Vet Res* 1989;50:161–165.

45. Marshall RB, Chereshsky A. Vaccination of dairy cattle against leptospirosis as a means of preventing human infections. *Surveillance* 1996;23:27–28.

46. Hjerpe CA. Bovine vaccines and herd vaccination programs. *Vet Clin North Am Food Anim Pract* 1990;6:171–264.