Short Communication: Behavioral and Physiological Indicators of Sensitivity or Chronic Pain Following Tail Docking¹

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ABSTRACT

Docking the tails of dairy cattle causes mild to moderate behavior changes and physiological indicators of acute pain, but no studies have investigated the possibility that tail docking may lead to chronic pain. In human amputees, an incidence of increased limb surface temperature is associated with phantom limb pain, a central nervous system representation that survives peripheral loss. The objectives of this study were to assess indicators of sensitivity or chronic pain in heifers by using behavioral indicators and thermography. We tested 14 Holstein heifers, 7 docked and 7 intact, from a previous neonatal tail-docking experiment. All 14 animals were videotaped during a test sequence of alternating cold (−9°C), hot (54°C), and neutral packs applied to the underside of the tail. Packs were placed approximately 30.5 cm from the tail head on all animals. A thermal image of the tail was taken using infrared imagery prior to and after temperature sensitivity testing. Docked heifers tended to have greater changes in surface temperatures following the test sequence than did nondocked heifers. In docked heifers, temperatures on the underside of the tail were higher than those at the tip of the tail, both prior to and following the test sequence. Docked heifers also showed substantially higher stomping activity following application of the cold pack. Shifting increased in intact heifers after application of the hot pack, but shifting of the docked heifers did not change. Greater changes were observed in the tail surface temperatures of the docked heifers following temperature manipulation, similar to human amputees who are experiencing phantom limb pain, indicating that similar mechanisms are present in the stump of the docked tail. The behaviors of docked heifers

indicated changes in their sensitivity to heat and cold.

Key words: chronic pain, sensitivity, tail docking, thermography

Although tail docking of dairy cattle is a common practice on US dairy farms, it continues to be an animal well-being issue in the United States. Several studies have shown that banding the tails, as a method to dock the tails of adult cattle, induces few detectable behavioral or physiological indicators of pain (Petrie et al., 1996; Eicher et al., 2000; Schreiner and Ruegg, 2002). Banding, followed by cutting off the necrotic tail after 7 to 14 d, is a typical method of docking tails in mature cattle. In addition to concern about the acute pain associated with the procedure (Tom et al., 2002), the ability of the cow to combat flies is an issue of well-being. Fly numbers on and some fly avoidance behaviors of docked cows have been shown to increase (Eicher et al., 2001). The behaviors of heifers docked at 3 wk of age indicated discomfort with the banding procedure (Eicher and Dailey, 2002). Stull and colleagues (2002) concluded that additional information is needed on increased sensitivity or chronic pain in docked cows to determine whether tail docking is a welfare problem.

As these calves mature, there is also the possibility of chronic pain or increased sensitivity resulting from a pathophysiological change similar to that seen in human amputees. When human amputees are reporting phantom limb pain, the affected limb shows an increase in surface temperature (Angrilli and Koster, 2000). This observation is exacerbated by testing and also by recalling the loss of the limb. With advancing infrared thermography, the capability of testing changes in the surface temperatures of tail stumps and intact tails is possible. Our hypothesis was that with tail manipulation, the surface temperature of docked tails would increase and that the tails would be more sensitive to heat or cold than controls. Our objectives in this study were to determine 1) sensitivity to hot or cold temperatures using behavioral observations and 2) changes in the surface temperature of the ventral side of the tails and the stumps following manipulation of the tails during sensitivity testing.

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Figure 1. Behavioral responses to a cold (-9°C) stimulus. Shifts, tail swings, foot stomps, and tail curves during the last minute of observation are shown as nontransformed LSM $\pm$ SE in panels a, b, c, and d, respectively. ^{a,b}Means within a time with differing superscripts differ, $P < 0.05$; *Means within a treatment differ over time, $P < 0.05$.

Calves from the Purdue Dairy Teaching and Research Center herd were blocked by birth date and randomly assigned to docked or intact treatments. All heifer calves were born between mid-May and mid-July and were housed in outdoor hutches. At 3 wk of age, one small band was applied to the tails of the docked group 10 cm below the vulva. After 3 wk, any necrotic tails that were still attached were removed by cutting. Cattle were housed and managed according to the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999). The experimental protocol was approved by the Purdue Animal Care and Use Committee.

When the pregnant heifers reached 22 to 23 mo of age, heat and cold sensitivity tests were conducted. Heifers were tested ($n = 7$ per treatment) on 1 of 3 consecutive days. On each of the days, an equal number of docked and intact heifers were tested. Docked and intact heifers were balanced for the testing sequence of a neutral pack, heat, a neutral pack, then cold, or a neutral pack, cold, a neutral pack, then heat. After confining each heifer to a chute, a thermal image (eMerge, Sebastian, FL) was taken for baseline temperature of the ventral

lower 10 cm of the tail of docked heifers and the corresponding area for intact heifers, and for the tip (stump) of the tail of docked heifers. A cold pack (Instant Cold Pack, Thera-Med, Waco, TX) or hot pack (Safe & Warm Incorporated, Seattle, WA) that had not been activated was then applied for 5 min as a neutral control. At that time, the pack was activated and allowed to remain on the tail for 5 min. Packs were placed beneath the tail for maximum exposure to the ventral side of the tail, and the tail and pack were wrapped with elastic wrap to keep them in place, allowing the handlers to move away from the heifer. The cold packs were 15×21.5 cm and the hot packs were 16×21 cm. The hot packs contained sodium acetate (food grade), water, and thickener and reached 54°C . The cold packs contained ammonium nitrate and water and reached -9°C . After 5 min, the second pack was activated and allowed to remain on the tail for another 5 min. The other unactivated pack (for the opposite temperature test) was then applied for 5 min to allow a return to baseline, and was then activated and left on the tail for an additional 5 min. At the end of that period, all packs were removed

Figure 2. Behavioral responses to a hot (54°C) stimulus. Shifts, tail swings, foot stomps, and tail curves during the last minute of observation are shown as nontransformed LSM $\pm$ SE in panels a, b, c, and d, respectively. ^{a,b}Means within a time with differing superscripts differ, $P < 0.05$; ^{c,d}Means within a time or change with differing superscripts differ, $P < 0.10$.

for 5 min. Finally, another image was taken of the ventral side of the tail and the tip for docked heifers.

Behavior was videotaped from the application of the first neutral pack (control) through the last temperature test. One-minute continuous samples from the last minute of the 5 min that were recorded were quantified for behavior (stomping, shifting, tail curving, and tail swings). These behaviors were chosen because of the restraint imposed by the chute during testing. Behavior was recorded using a camcorder (OmniMovie HQ; Panasonic, Secaucus, NJ) mounted on a tripod that was placed 1.8 m behind the chute. All behaviors were recorded as events. Stomping was recorded when a foot was lifted up and down in place. Shifting was scored when body weight was transferred but none of the feet were lifted. Tail curving was recorded when the tail was pressed into the body or was curved to one side but no tail swinging was involved. Tail swings were recorded when the tail was moved to one side and returned to midline, and each movement to and from midline was recorded as a swing. Behavior and thermography data were analyzed as a randomized com-

plete block with the GLM procedures of SAS (SAS Institute, 1999).

Sensitivity testing in this study revealed some differences between docked and intact heifers during both the hot and cold applications. These data were log transformed for analysis and are presented as nontransformed means. Stomping was greater for the docked heifers during the cold pack application (Figure 1; $P = 0.03$). Sensitivity to stimuli (hyperalgesia) can result when damaged or neighboring nerve fibers are sensitized or when they fire ectopically. Previously, tail-docked heifers were found to exhibit the mechanisms of shifting and stomping to compensate for not having a tail to displace flies (Eicher et al., 2001).

In this study, shifting did not differ between intact and docked heifers during baseline sampling (Figure 2). After the heat application, shifting increased from baseline for the intact heifers ($P < 0.05$) and was greater than for the docked heifers ($P < 0.05$). Analgesia can result in a reduced response to heat and may indicate chronic pain (Rittner et al., 2005). Leukocytes may be involved when opioids are secreted in stressful condi-

Table 1. Temperatures (LSM) of the ventral surface of the tails and tail tips of docked heifers and the ventral surface of intact heifers during baseline and after the application of hot and cold packs

Treatment	Baseline, °C	Intact, °C	Change, °C
Intact	34.2 ^a	35.1 ^{a*}	0.97 ^{a*}
Docked	34.6 ^a	36.1 ^{a*}	1.43 ^{a*}
Docked tip	32.2 ^b	32.1 ^b	-0.03 ^b

^{a,b}Means of the ventral surface differ from the docked tip ($P < 0.05$).

*Means of intact and docked treatments differ ($P < 0.10$).

tions (such as the heifer's movement into the chute), which can ultimately inhibit the excitability of sensory nerves and the release of excitatory neuropeptides. To our knowledge, this has not been investigated for docked cows. In a previous work, Eicher et al. (2000) found that shortly after mature heifers were banded, their free cortisol concentrations were suppressed and leukocyte phenotypes were altered; however, chronic effects on the leukocytes have not been documented. The ambient temperatures were very warm on test days, beginning at around 26.5°C, and were higher than 32°C each day during testing (which was completed before 1200 h). Additionally, the humidity was higher than 80% throughout the testing.

The number of occurrences of tail curving was greater for the intact and docked heifers following the application of heat and cold than at baseline ($P < 0.05$) but did not differ between treatments from the baseline to the test during both the hot and cold testing. This observation may be an artifact of the docked tail being shorter and obviously less capable of being curved, although observations were made of the same area of the tail. In addition to the possibility that the docked heifers may not have had the physical mechanism to curve the tail when it was docked, the intact heifers may have been demonstrating sensitivity to the packs whereas the docked heifers may have had suppressed sensitivity.

During the cold test (Figure 1), the docked heifers demonstrated increased sensitivity, with more stomping ($P < 0.05$). Swinging the tail occurred most frequently during the observation period, but did not differ between the baseline and test periods or between treatments. The thermographic temperatures of the underside of the tails did not differ ($P = 0.96$) between the docked and intact heifers prior to manipulating the tails during testing (Figure 3, Table 1). The tip (stump) of the tail of docked heifers was at least 2°C cooler than the underside of the tails of both intact and docked heifers. After sensitivity testing, the tails of the docked heifers remained 1.43°C warmer than at baseline, whereas the tails of the intact heifers were 0.97°C warmer than at baseline. After testing, the tail surface

Figure 3. Thermographs of an intact (top panel) or docked tail (middle panel) and a docked tail tip (bottom panel). Colder areas are blue and green and hotter areas are red.

temperature tended to be higher for the docked heifers ($P = 0.09$). Testing the tail surface temperature under neutral or cold environmental temperatures may produce different results for sensitivity. Blood flow to the surface is one of the first resistance mechanisms to heat and inflammation and may be associated with neuropathic pain (Mogil et al., 2005; Rittner et al., 2005). These results also correspond with the results of a histological analysis performed on the tails of these same heifers, which showed neuromas and tangles in the stumps of the docked heifers (H. W. Cheng and S. D. Eicher, unpublished data), similar to studies of docked pig tails (Simonsen et al., 1991). Behavioral changes indicating increased sensitivity to heat or cold demonstrated increased sensitivity of the docked heifers' tails. Trends toward greater changes in the surface temperature following manipulation were observed in heifers with docked tails, similar to human amputees when experiencing phantom limb pain, indicating that similar mechanisms are present in the stump of the docked heifer.

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