Association between fecal indicator bacteria in water and cattle grazing management and spatial factors in the Sierra Nevada meadows of California

Anyarat Thiptara[1,2] Philip H. Kass[1] Kenneth W. Tate[3] Edward R. Atwill[1]

[1] Department of Population Health and Reproduction, School of Veterinary Medicine, University of California, Davis, CA, USA

[2]Epidemiology Section, Southern Veterinary Research and Development Center, Thung song, Nakhonsithammarat, Thailand

[3]Department of Plant Sciences, College of Agricultural and Environmental Sciences, University of California, Davis, CA, USA

Study Background

Fecal indicator bacteria (FIB), such as *E.* coli are normal microorganisms found in gastrointestinal tracts of warm-blood animals and humans. FIB can be used as indicators for fecal contamination in water. The US Environmental Protection Agency (USEPA) has used FIB to regulate and monitor the water quality across the US. The objective of this study was to evaluate the association between FIB concentrations and cattle grazing management, environmental and hydrological conditions, resource use activities, and spatial factors.

Study Areas

We conducted this research between 25 May and 1 November 2011 (Roche et al., 2013). There were 144 water collection sites, which consisted of 44 different streams in 15 grazing allotments on US Forest Services-managed public lands. The study allotment acreage was approximately 1,472 km^2 with 1,730 cow-calf pairs.

Study Design

This study was a panel study (a series of cross-sectional samples). One liter of water was collected on a monthly basis (visit) and analyzed for FIB (fecal coliforms, *E. coli*). FIB concentrations were reported as CFU/100 ml. We paired the sites and determined them as either upstream or downstream by stream flow direction. Seventy-two pairs of the sites generated with 330 water-pair samples.

Grazing management and spatial factors

Cattle grazing was either absent or present from allotments. The distance (m) between the pairs was calculated. Key grazing and concentrated recreation areas within 200 m of streams were identified. Concentrated recreation areas included campgrounds, swimming areas, trailhead, and pack animal stations. The sample collection sites were evaluated for heavy use by cattle, humans or both. Environmental conditions and/or resource use activities were recorded on the sample collection dates as present or absent. The conditions and activities included stagnant-low stream flow, turbid stream water, recreation (i.e., swimming, camping, hiking, fishing, hose riding), cattle, and precipitation.

Statistical Analyses

We used Stata/IC 12 for all analyses. FIB concentrations at downstream and upstream were the dependent and main independent variables, respectively, in regression analyses. We specified pair ID as a group variable and visit as a time variable and then used a robust general estimating equation (GEE) negative binomial regression with unstructured correction to evaluate their relationships.

Study Results

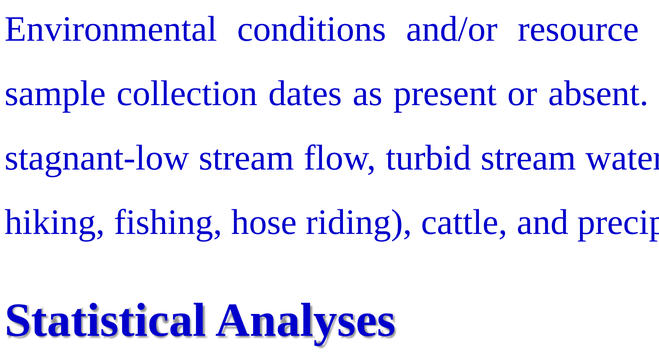


Figure 1. The estimated mean *E. coli* downstream concentration regarding cattle status on allotments (cattle on, cattle off), turbid stream water condition on the sample collection dates and *E. coli* upstream concentrations.

Figure 2. Study areas

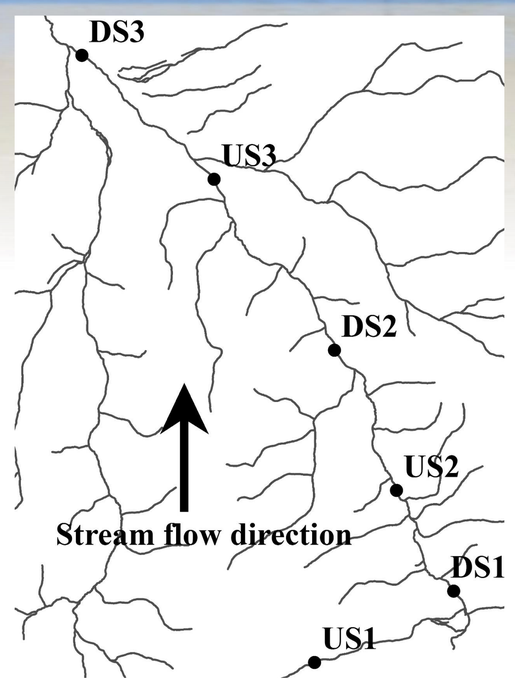
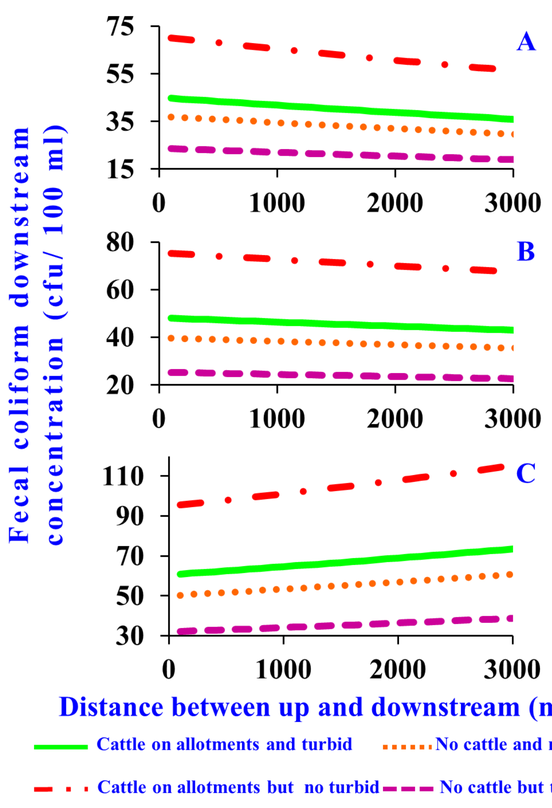


Figure 3. Upstream (US) and downstream (DS) pairs using stream flow direction

Figure 4. Estimated mean fecal coliforms downstream concentrations regarding cattle status on allotments (cattle on, cattle off), rain condition on the sample collection dates, distance between up and downstream pairs, and fecal coliforms upstream concentrations. The estimated means decreased 7.3 and 3.7% for every 1,000 m increase in the distance between up-downstream pairs when fecal coliform upstream concentrations were set at the 1st (A) and 2nd (B) quartile values, respectively. However, the estimated means increased 6.7% for every 1,000 m increase in the distance between up-downstream pairs when fecal coliform upstream concentrations were set at the 3st quartile value (C).



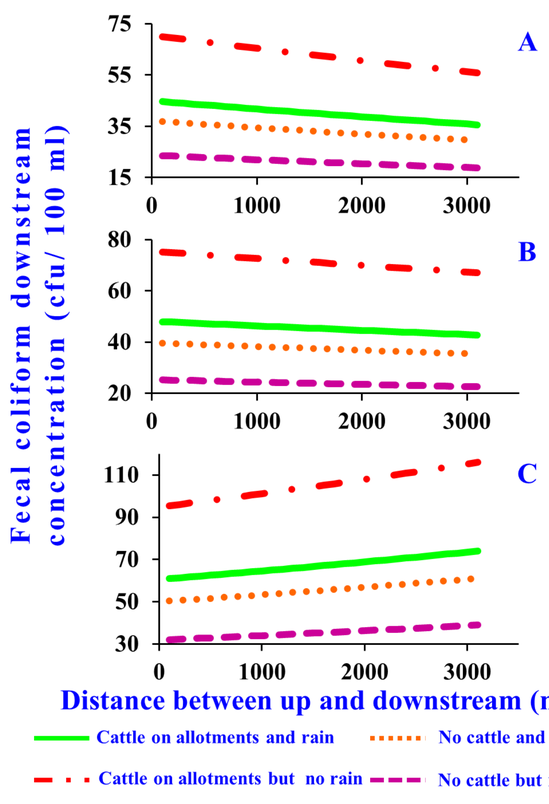


Figure 5. Estimated mean fecal coliform downstream concentrations regarding cattle status on allotments, turbid stream water condition on the sample collection dates, distance between up and downstream pairs, and fecal coliform upstream concentrations. The estimated means decreased 8.3 and 4.0% for every 1,000 m increase in the distance between up-downstream pairs when fecal coliform upstream concentrations were set at the 1st (A) and 2nd (B) quartile values, respectively. However, the estimated means increased 8.6% for every 1,000 m increase in the distance between up-downstream pairs when fecal coliform upstream concentrations were set at the 3st quartile value (C).

Study Conclusion

Livestock grazing and upstream turbid condition elevated fecal coliform pollution in surface water while precipitation was more likely to decrease the pollution. For *E. coli*, upstream turbid seemed to have more positive relationship than livestock grazing.

Acknowledgements

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