Moreover, these canines scavenge on dead yaks in winter. In public slaughter houses available in Tibet, domesticated dogs on their yak herd to support their livelihood. Although E. granulosus as multilocularis infections. Multilocularis technique that discriminate between both parasites and the causative species is often misidentified when the metacestode is poorly developed in unsuitable intermediate hosts.

The yak Bos grunniens, a bovid species, inhabits steppes of the Himalayan highlands and was domesticated in Tibet about 3,000 years ago. The native people are totally dependent on their yak herd to support their livelihood. Although public slaughter houses are available in Tibet, domesticated yaks are frequently killed in individual households. Their viscera discarded carelessly become baits for dogs and foxes. Moreover, these canines scavenge on dead yaks in winter. Thus, living with canines in grasslands is a risk factor of echinococcosis for Tibetan livestock farmers.

Shiqu County, located in Qinghai-Tibet plateau region of western Sichuan in China, is a highly endemic area for both cystic and alveolar echinococcosis. Based on gross and microscopic appearance, liver lesions in 6 (6.2%) of 97 yaks from Shiqu County were tentatively identified as E. multilocularis. The presence of E. multilocularis in humans and other hosts from the same region have supported this assumption. In another survey including a neighboring region (Ganzi County), echinococcal lesions were detected in 221 (51.5%) of 429 yaks. These were morphologically classified as E. granulosus-like polycystic types (50.8%, 218 of 429) and E. multilocularis-like alveolar types (0.7%, 3 of 429). Therefore, we attempted to confirm identification using molecular techniques that discriminate between E. granulosus and E. multilocularis infections.

A presumptive echinococcal liver lesion from a domesticated yak in Shiqu County was transported to our laboratory for molecular typing of the Echinococcus species. The lesion was characterized by small alveolar vesicles and necrotic areas (Figure 1A). An intense fibrogenesis was observed around the vesicles in which germinal layers were poorly developed (Figure 1B). These features were similar to those of human lesions caused by E. multilocularis. The occurrence of abnormally developed E. granulosus lesions in cattle was described earlier by Vogel, who pointed out their superficial similarity to the metacestode of E. multilocularis. He suggested that these lesions should be referred to as “multicystic” or “multivesicular” rather than “multilocular.”

Genomic DNA was extracted from the lesion by using the DNeasy tissue kit (Qiagen, Hilden, Germany) and then used as a template for a polymerase chain reaction (PCR). Mitochondrial genes of Echinococcus species were amplified by using the following primer pairs: primers F/CO1 (5′-TTGAATTGCCCAGCTTGAAGTC-3′) and R/CO1 (5′-GAACCTAAGCACATAACATAATCG-3′) for cytochrome c oxidase subunit 1 (cox1) gene, and primers F/Cytb (5′-GTCAGATGTCTTATGTTGGCTGC-3′) and R/Cytb (5′-TCTGCTGACACCCACCTAAAATA-3′) for cytochrome b (cytb) gene. The PCR was carried out in a 50-μL reaction mixture containing 2 μL of template DNA, 200 μM of each dNTP, 0.2 μM of each primer, 1 unit of Taq polymerase (Ex Taq; TaKaRa Biomedicals, Tokyo, Japan), and Ex Taq reaction buffer. For PCR amplification, we used 35 thermal cycles (94°C for 30 seconds, 54°C for 30 seconds, and 72°C for one minute). The PCR amplicons were directly sequenced by using a dye terminator cycle sequencing kit (DYEnamic ET Terminator; Amersham Biosciences, Tokyo, Japan) and an ABI PRISM 377 sequencer (Perkin Elmer Applied Biosystems, Foster City, CA).

As shown in Table 1, partial sequences of cox1 (795 base-pairs) and cytb (568 basepairs) genes obtained from the yak lesion were compared with previously reported sequences of Echinococcus species. Both sequences were identical with...
those of the *E. granulosus* G1 genotype (sheep strain); however, a transitional change (CT) at position 532 occurred in *cox1* gene and a transversional change (C/A) at position 140 occurred in the *cytb* gene. These data confirm that the yak was infected with the sheep strain of *E. granulosus*, rather than *E. multilocularis*. The result is consistent with the observation that yaks are kept with sheep in Shiqu County.

Previous molecular studies have revealed a number of diverse genetic strains of *E. granulosus*. To date, eight distinct genotypes (G1–G8) have been identified. Among them, G1 and G6 (camel strain) genotypes have been previously recorded in China. The fertile cysts of yaks were identified as the *E. granulosus* G1 genotype, suggesting that yaks significantly contribute to the transmission of cystic echinococcosis in China. However, as shown in this study, it is suggested that the yak is not an adequate host, since metacestode development in the yak is arrested. The identification of echinococcal lesions in yaks as *E. granulosus* rather than *E. multilocularis* should be confirmed by molecular typing of a larger number of samples because domesticated yaks are grazed widely in areas where *E. multilocularis* is known to occur in small mammals and canines. The precise understanding of *Echinococcus* species in domestic animals is important for control of echinococcosis in China.

**Received May 21, 2003. Accepted for publication August 5, 2003.**

**Acknowledgment:** We acknowledge the contribution of Dr. Robert L. Rausch whose experience with echinococcal lesions in “aberrant hosts” assisted this investigation.

**Financial support:** This study was supported by the National Institute of Health (1R01 TW01565-01; Principal Investigator, Philip S. Craig) and by Grants-in-Aid from the Ministry of Education, Science, Sports, and Culture of Japan and the Japan Society of Promotion of Science to Akira Ito (1255702414 and 14256001).

**Authors’ addresses:** Ning Xiao, Minoru Nakao, Kazuhiro Nakaya, Hiroshi Yamasaki, Yasuhito Sako, Wulamu Mamuti, and Akira Ito, Department of Parasitology and Animal Laboratory for Medical Research, Asahikawa Medical College, Midorigaoka-Higashi 2-1, Asahikawa, 078-8510, Japan; Telephone: 81-166-68-2420; Fax: 81-166-68-2429; E-mail: akiraito@asahikawa-med.ac.jp. Jianmin Qiu, Sichuan Institute of Parasitic Diseases, Chengdu 610041, Sichuan, China. Peter M. Schantz, Division of Parasitic Diseases, National Center for Infectious Diseases, Centers for Disease Control and Prevention, 4770 Buford Highway, Atlanta, GA 30341. Philip S. Craig, Bioscience Research Institute, School of Environment and Life Sciences, University of Salford, Great Manchester, M5 4WT, United Kingdom.

**REFERENCES**