March 2006

Is This Safe To Eat?

Chapter 5

Is This Safe to Eat?

"A crust eaten in peace is better than a banquet attended by anxiety."
(Aesop, 6th century B.C.)

"There is no love sincerer than the love of food." (George Bernard Shaw)

Photo by Milton Friend

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Chapter 5

Is This Safe to Eat?

The harvest and consumption of wildlife is as old as humankind and often has sustained human exploration into unsettled areas. Wildlife still remain a primary foodbase for many native peoples throughout the world. From shellfish to bear, humans today continue to hunt, fish, and otherwise harvest wildlife for recreation, social and cultural needs, dietary supplementation, subsistence, and other purposes that result in the consumption of game meat (Fig. 5.1).

Over time, experience has taught people what food is safe to eat and how it should be prepared. This is especially true for those who subsist upon wildlife. Fortunately, the meat from wildlife generally is safe to eat when properly harvested and prepared; however, many people infrequently consume wildlife and are less experienced than subsistence users of wildlife in making judgments about what is safe to eat, how to handle the meat between the times of harvest and preparation, and how the meat should be prepared (Table 5.1). Disease emergence and resurgence has added a dimension that also must be considered for wildlife (e.g., chronic wasting disease in deer and elk) and domestic foods alike (see Chapters 2 and 3).

This chapter provides guidance for sporadic consumers of wildlife because, unlike farmed food animals (domestic and captive-reared wildlife species) or commercially harvested finfish and shellfish, the meat from free-living wildlife in the USA and many other countries is not regulated and inspected by government authorities. The safe consumption of game harvested by the public in these situations depends entirely on the actions and discretion of those harvesting and preparing these food items. These individuals commonly encounter conditions in wildlife carcasses that cause them to ask the question "Is This Safe to Eat?" (Fig. 5.2) and in some situations to unnecessarily discard edible meat.

Recreational harvest of wildlife and **ecotourism** (see Chapters 2 and 3) are two situations where knowledge about the wholesomeness of wildlife food items is beneficial. Relevant insights can be gained from the Internet, publications such as this one, and agency health advisories associated with wild game. Recommendations and guidelines developed by health specialists should be heeded. Most importantly, when in doubt about the safety of the meat, "play it safe" and dispose of the meat in a responsible manner, rather than consume it.

Do not feed "tainted" meat to **companion** or farm animals because that could jeopardize their health and result in those animals becoming diseased and infecting others. Unfortunately, no matter how much we know about the meat being considered for consumption, there always will be some degree of risk. Some hazards can be invisible and thus, at times, impossible to avoid (e.g., eggs and salmonellosis, hamburger and *Escherichia coli*).

General Guidelines

"What you don't know can hurt you" (Anonymous)

"Knowledge is the antidote to fear…" (Ralph Waldo Emerson)

The following general guidelines regarding the harvest and preparation of wild game meat apply to all species and geographic areas despite this chapter's focus on North American vertebrates. Invertebrates, like shellfish, are important food items in many parts of the world and also are subject to a wide array of diseases (see Chapter 2). These species are **filter feeders** and, in underdeveloped countries, they are found in water often contaminated by human waste. Also, worldwide, harmful algal blooms that produce toxins hazardous to humans can contaminate their habitat. Therefore, shellfish harvesters need to be well-informed about environmental conditions where they are harvesting shellfish. Hepatitis and various forms of shellfish poisoning can result from ill-informed choices involving the harvest and consumption of clams, oysters, and other species.

Learn About the Local Area

Individuals harvesting wildlife should be well informed about wildlife disease activity and concerns in the local area where harvest is being pursued. This holds true for the patch of woods in the "back forty," as well as for a safari in Africa. For example, appropriate inquiry could inform a novice hunter in Arkansas that the bacterial disease tularemia is present in that state. The hunter could then take appropriate precautions when handling wild rabbits or rodent species and also avoid exposure to ticks and other potential vectors of tularemia. Fishermen who check local water conditions often can obtain information about contaminant levels and health advisories about the safe amount of fish to be eaten from that area.

Know Whom to Contact

Wildlife consumers can contact local public health authorities and the local fish and game agencies to pursue questions or concerns about the health status of wildlife.

Learn Proper Handling and Preparation

Quality care of carcasses in the field and proper technique for removing internal organs and other viscera are important for maintaining the quality of the meat to be consumed. Learn these techniques from an experienced person when possible. Wildlife extension and hunter education specialists within universities and state wildlife agencies often are good sources for information on how to handle wild game in the field and prepare it for the table.[1] Various extension bulletins, pamphlets, and other publications addressing these matters are available. For example, *A Bibliography of Cooperative Extension Service Literature on Wildlife, Fish, and Forest Resources* is a comprehensive list of relevant publications from all over the USA.[2] Another good source for finding wildlife related resources is http://www.uwex.edu/ces/wlb. Guidance also can be obtained from sportsman-related manuals and video tapes.

Consider how much time will lapse between actual harvest of the animal, cleaning, and proper storage prior to transport to the site where it will be prepared for food. Field and weather conditions are important aspects of this evaluation, as decomposition increases with temperature. Also, blowing dust, **flies**, and other field conditions may require protective bags and other containers to protect the carcass. Ambient temperatures may also require refrigeration or other means for cooling carcasses to prevent spoilage.

Figure 5.1 Game meat serves the food, cultural, and social needs for a wide variety of peoples.

Internal organs and intestines from large mammals, such as deer, should be completely removed immediately after harvesting the animal. In warm climates, it is advisable to "field dress" large game birds and medium-sized animals as well. Care should be taken not to rupture the stomach, intestines, or other internal organs. Thoroughly clean the inside of the carcass if wounds associated with the animal's harvest or removal of viscera have resulted in their rupture and soiling of the body cavity. Cut away and discard hemorrhaged tissue from wounds as these tissues may contain lead and other bullet and shot fragments.

Wear disposable gloves to prevent skin contact with viscera and blood from animal carcasses when field dressing and preparing carcasses for consumption (Fig. 5.3). Abrasions on the preparer's skin allow bacteria and other pathogens present in the carcass to cause infection, if skin protection is inadequate. Preventing skin contact with the carcass by outer clothing also can serve as a barrier from ticks and other ectoparasites.

When cleaning wild game, dispose of unwanted parts responsibly to avoid endangering local domestic and wild animals. For example, discarding the viscera from cottontail rabbits in a manner that allows dogs or other **carnivores** to feed on that material facilitates the life cycle of a common tapeworm (Fig. 5.4). Similarly, fish-cleaning stations are commonly provided at some boat launching areas for the disposal of unwanted fish parts.

Various techniques are used to preserve and prepare game meat for consumption. Basic understanding of the proper application of techniques is important for avoiding health problems (Table 5.2). For example, smoking meat is a popular way to prepare fish and game, although, if done

Table 5.1. Characteristics of game-meat consumers in the USA and sources for that meat.

Consumer type	Typical role of game meat in diet	Primary source of meat	Primary harvest of meat	Primary origin of meat	Comments
Subsistence	Primary source of animal protein	Wild	Personal	Local to regional	Individuals (primarily native peoples and those living in remote areas) are usually knowledgeable about harvesting, processing, and food preparation; practical knowledge of species being harvested and the appearance of normal body conditions.
Supplemental	Frequent and important source of animal protein	Wild	Personal	Local to regional	Same as subsistence and includes larger percentage of general public in locations such as Alaska where there is an abundance of wildlife and relatively few people.
Recreational	Occasional source of animal protein	Wild	Personal	Local to international	Many individuals infrequently harvest wildlife and may have little knowledge of their diseases. Levels of knowledge vary and range from high to low.
Novelty	Infrequent novelty food	Wild	Other	Local to international	Meat typically provided by friend who harvests wildlife; consumer with very limited information relative to harvest conditions and care of meat.
Cultural	Important component to satisfy food needs	Wild/ commercial	Other	Local to international	Meat, organs, powders, and other consumables from wildlife for medicinal, spiritual, sexual, and other purposes. Primary native peoples; minority of general public.
Gourmet	Low frequency specialty cultural mores	Commercial	Other	Local to international	Generally government inspected foods from farmed, ranched, and sometimes wild stocks of animals.
General public	Commercial products	Commercial	Other	Local to international	Government inspected foods; finfish and shellfish primary species involved. Product may be from captive or wild stocks depending on species.

improperly, can result in serious consequences. Improper smoking of fish, commercial and individual, from the Great Lakes (North America) has resulted in human fatalities caused by type E botulinum toxin.[3–6] The temperature during the smoking was not high enough for a long enough period of time to inactivate *Clostridium botulinum* toxin. Regulations for commercial smoking of fish within the USA have been adjusted to provide safer products from this process. Home smoking is controlled by the individual.

Other general precautions with hunted game include considerations involving bullet fragments and shotshell pellets present in tissues of harvested animals. Lead shot used for bird hunting has been the cause for cases of appendicitis in people who have ingested this shot along with the meat.[7] This shot has a tendency to lodge in the appendix and cause a rupture; it is not a cause for lead poisoning in people. However, shot and bullet fragments can be embedded in meat and can cause chipped and broken teeth if bitten into. Finally, it is unwise to consume animals found dead if the cause of death is unknown. An experienced person may be able to evaluate a "freshly dead" carcass and determine the cause of death, thereby salvaging the meat for consumption when appropriate. However, seldom is such action warranted.

Photos by Milton Friend

Figure 5.2 Questions about the safety of game meat may arise after animals have been harvested and possible abnormalities are seen, or because disease events in the region cause higher awareness.

Photo by James Runningen

Figure 5.3 The use of disposable or reusable impermeable gloves affords a great deal of protection at little expense and inconvenience when processing wildlife carcasses in the field and when handling the meat and tissues from these animals prior to their being prepared as food.

General Risk Assessment

Below are three recommendations for hunters to evaluate the health of their quarry:

1) Before the animal actually is killed, its behavior and general appearance should be noted. Sick and, of course, dead animals should not be harvested for food consumption. However, a decision should be made at the time as to whether problematic animals should be left alone or collected for evaluation purposes. Circumstances will dictate what should be done, and it is important not to violate any regulations regarding taking and possessing wildlife. Whenever apparent disease conditions are encountered, local wildlife authorities (e.g., wildlife agencies) should be notified.

2) At the time of harvest, thoroughly inspect the outside of the carcass.

   External Exam:

   - Do the haircoat, feathers, or other body coverings look healthy? (Fig. 5.5A, B)
   - Is the animal in good body condition or is it very thin or emaciated? (Fig. 5.5C, D)
   - Are abnormal conditions present, such as growths, deformities, or injuries? (Fig. 5.5E–K)
   - Are there other signs of illness, such as evidence of diarrhea (abnormal looking or soft stool adhered to the vent area)? (Fig. 5.5L, M)

   When conducting external examinations, it is important to recognize that infectious disease is not the only cause for unfit appearance of an animal. Old age, malnutrition, mechanical injury,

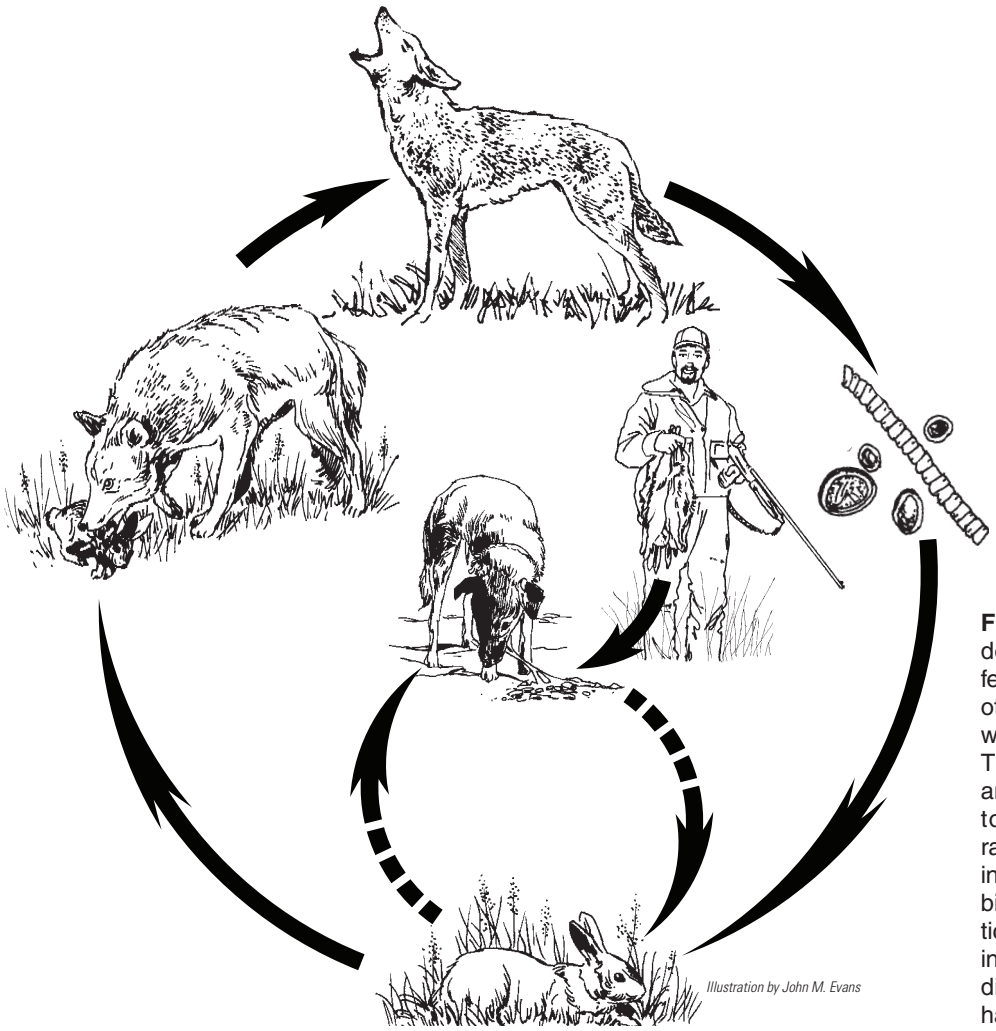


Figure 5.4 Infective eggs of the dog tapeworm are shed in the feces of carnivores, such as coyotes, and are ingested by rabbits while feeding along the ground. The eggs hatch within the rabbit and the resulting larvae migrate to various tissues within the rabbit's body. Carnivores become infected when they consume rabbits containing these larvae (cysticerci). Dogs commonly become infected by feeding on improperly discarded remains from rabbits harvested by hunters.

and physical defects that inhibit food gathering and eating are among other factors that can lead to this type of appearance. For example, fish with **lamprey** scars may be thin because of the lamprey's effects on the fish (Fig. 5.6).

Tumors on some fish (Fig. 5.7) have been associated with environmental contaminants;[8,9] if tumors are found, check whether fish consumption advisories have been issued for the respective area. Consider observations made during the external examination, along with those from the internal examination, in deciding about the suitability of the meat for consumption. Carcasses that appear to be grossly diseased should not be opened for internal examination.

3) After harvest, and following the external exam, the inside of the carcass should be inspected when the animal is field dressed or otherwise processed.

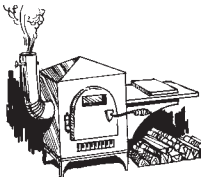
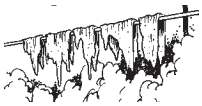
Internal Exam:

- How does the carcass smell?
- Do any of the tissues or organs appear irregular or abnormal in shape or color? (Fig. 5.8A–F)
- Do any of the tissues or organs appear to contain abscesses? (Fig. 5.8G)
- Are there any tissues or organs that contain what appear to be parasites? (Fig. 5.8H–J)

Use all of your senses when examining a carcass. Bad odors generally arise from rotting tissues, perhaps from an old injury that has abscessed. However, the spillage of intestinal tract content into the body cavity during removal or from rupture during harvest may also be the source for such odor. The food source of the animal may also result in strong odors that are not an indication of disease. Cedar, sagebrush, and bivalves (mussels) are examples of foods consumed by

Figure 5.5 Aberrations in hair/feather coat, emaciated body condition, deformities, "sores", and soiling of the vent area are common external indications that an animal may be afflicted by disease. (A) The extensive loss of feathers on the head of this loon is believed to have been caused by ringworm resulting from infection by *Trichophyton* sp. fungi. (B) The white, wooly-like hair within the hair coat of this white-tailed deer also is aberrant, but has genetic rather than a pathologic basis. (C) Emaciation such as that seen in the breast of the lower pheasant and (D) by the rib cage of this gray wolf may result from food deprivation (malnutrition), chronic infectious diseases, and other causes. (E) The shorter than normal lower jaw of this white-tailed deer is genetic, while the deformed upper portion of the bill on this white pelican (F) was likely caused by injury rather than infectious disease. In contrast, (G) the nodule on the face of this canvasback duck was caused by avian tuberculosis. (H) The greatly swollen mammary glands of this white-tailed deer (mastitis) and (I) the swollen lower portions of the feet of another white-tailed deer are caused by different types of pathogenic bacteria capable of causing disease in humans. Handling these types of animals without protective gloves is hazardous as contact with drainage from infected areas can cause human infection through abrasions in the skin. (J) The lesion on the tongue of this white-tailed deer was caused by bluetongue virus, one of the causes of hemorrhagic disease in deer, livestock, and some other mammals. (K) The lesion under the tongue of this mallard duck was caused by duck plague virus. (L) The blood-soiled vent area of this mallard duck also is due to duck plague, a viral disease of waterfowl and (M) the green soiled vent area of this Canada goose is due to lead poisoning.

Table 5.2 Common techniques for home preparation of game meat within the USA[a,b]

Method	Description	Species commonly prepared	Comments
Smoking 	Meat is brined for several days to weeks and then placed in a closed but vented chamber where it is heated for hours to several days. Flavoring results from the type of wood/sawdust used for specifically creating smoke during the heating process.	Many types of meat including venison, birds, fish, and occasionally shellfish.	Homemade and commercial smokers, including small volume electric units are used. Insufficient heating relative to temperature reached and time that highest temperature is maintained fails to kill spore-forming bacteria that may be present.[38,39] Human cases of botulism (*Clostridium botulinim*) have resulted from home-smoked fish and other game meat.[3,5]
Jerky 	Typically, uniform thin strips of lean meat that have been air dried, often following a prolonged period of brining (several weeks). Smoking is commonly used as a part of the drying process.	Deer, caribou and other large mammals.	Popular for venison and sometimes used for novelty preparation of species not typically prepared for food. Insufficient heating during the drying process may result in the survival of larval forms of parasites encysted within game meat along with contamination by bacterial organisms during processing of the carcass. Examples include human cases of trichinellosis from the consumption of cougar jerky[40] and *Esherichia coli* 0157:H7 from venison jerky.[41]
Sausage 	Highly seasoned minced game meat, such as venison, combined with domestic beef and /or pork to increase fat content. This mixture is usually stuffed in casings of animal intestine and then cold smoked (low temperature) for several days and then finished by hot smoking (cooking temperature) for 24 hours.	Same as jerky.	Popular use for less prized cuts of game meat from deer and elk. Commonly served as snacks at the homes of hunters, distributed to friends, and used as sandwich meat. Because of the relative low meat temperatures (about 150°F) reached during preparation, it is important that both the game and domestic meat be from wholesome animals. Secondary bacterial contamination that may occur when processing the carcass is especially important and requires that basic sanitation be incorporated throughout all aspects of processing the animal and during sausage preparation.
Canning 	Previously treated (cooked, cured) or raw meat is heated in a sealed container to exclude air.	Same as smoking.	"Canning is the oldest and most important means of preparing ambient, stable long shelf-life foods."[42] *Clostridium botulinium* is the pathogen of greatest concern for the commercial canning industry[43] and also for home-canning. The anaerobic environment resulting from canning facilitates the germination of *Cl. botulinium* spores that may be present. The combination of temperature and time required to destroy botulinum toxin produced by these bacteria is 212°F for 10 minutes.[39] The thermal death time for spores of *Cl. botulinium* at 250°F is 2.45 minutes. These temperatures must be maintained at the center of the interior of the container.[38]
Direct cooking 	Essentially all methods used for cooking domestic meats (fish, poultry, beef, etc.) are used to cook game meat.	Mammals, birds, fish, shellfish and incidental species, such as frogs and turtles.	Game meat is often eaten rare to maintain the delicate flavors of different meats or prevent drying due to the low fat content of many species. Proper handling, including temperature control (refrigeration/freezing) to prevent spoilage and secondary bacterial contamination is important for sustaining the wholesomeness of the meat.[44]
Other 	A variety of other techniques such as salting, fermentation and other processes are used to prepare game for consumption.	Various	Use of these techniques is generally less common than the above techniques except for regional and ethnic/cultural preferences. Similar cautions identified for the above techniques apply. Detailed information about various methods for food handling and preparation that apply to game meat is available from many sources and should be consulted when considering unfamiliar methods.[38,39,44,45]

[a]Game meat is generally wholesome. All of the methods identified in this table are generally safe when properly applied. Unlike domestic meats, the health status of the animal is not known nor is there a regulatory inspection process to evaluate game meat. Therefore, the burden for inspection and quality control from harvest through processing and food preparation lies with those involved in the utilization of game meat.

[b]Extreme examples of the edibility of meat from wild mammals are reports of meat eaten from a young mammoth frozen in the Siberian tundra for about 15,000 to 20,000 years and bone marrow from a horse that had been frozen in Alaska for 50,000 years and was served at a dinner in New York.[39]

wildlife that may make them smell odd, but do not represent potential human health hazards. The appearance of internal organs and tissues is often compromised by damage during the harvest of the animal and may be difficult to evaluate. However, the appearance of abscesses, fungal growth, and tumors within the body cavity should generally result in the rejection of the carcass for consumption.

"Conditions/Things" One Might Encounter

"Nature does nothing without a purpose" (Anonymous)

"Neurosis seems to be a human privilege" (Freud)

Most wildlife are wholesome and do not pose any significant risks for disease when cleanly harvested, properly handled, and prepared appropriately as food. Nevertheless, there are a number of conditions of wildlife that may be encountered. Some are harmless, but cause uninformed observers to discard edible meat. Others are potentially hazardous. Some of the conditions commonly seen within the USA are highlighted in the remainder of this chapter.

Photo courtesy of the U.S. Environmental Protection Agency, Center for Great Lakes and Aquatic Sciences

Figure 5.6 Those not familiar with lamprey-induced wounds may mistake the lesions in the flesh of fish to have been caused by disease agents instead of the attachment and detachment of lampreys.

Parasites

Parasites generally are more apparent than other pathogens to those processing wildlife for their meat and other purposes. Parasites, or evidence of their presence, may be seen externally on the animal and internally within the intestines, on major organs such as the liver, and as a result of cyst formation within muscle tissue (Table 5.3). If present, people may want to know what they are and whether it is safe to eat the meat from this animal.

External Parasites

Most people are not surprised or concerned when they encounter ectoparasites, such as ticks and lice (Fig. 5.9) on wildlife carcasses. However, that is not the situation when larval forms of bot and warble flies are encountered for the first time. Depending on the fly species and wildlife host, these larvae may be encountered in nasal cavities, sinuses or **retropharyngeal pouches**, subdermal, and even in muscle tissue.[10] Despite the outward appearance (Fig. 5.10), the meat from infested carcasses is safe to eat.

Sarcoptic mange (*Sarcoptes scabiei*) is another external parasitism that causes considerable concern (Fig. 5.11).[11] Infestation does not, by itself, render the animal unfit for consumption, but severe infestations can result in unhealthy animals and secondary infections by opportunistic bacteria can render such carcasses unfit for consumption. Protective gloves should always be used when handling animals with mange, because some of the subspecies of mites that cause this disease are capable of transient human infestations.[11]

A. Photo by Stephen B. Smith, USGS

B. Photo by Milton Friend

Figure 5.7 (A) Tumors within the mouth area of some fish, such as the brown bullhead, have been associated with environmental contaminants; (B) the tumor on this northern pike is of unknown cause. Fish that have external tumors should not be consumed.

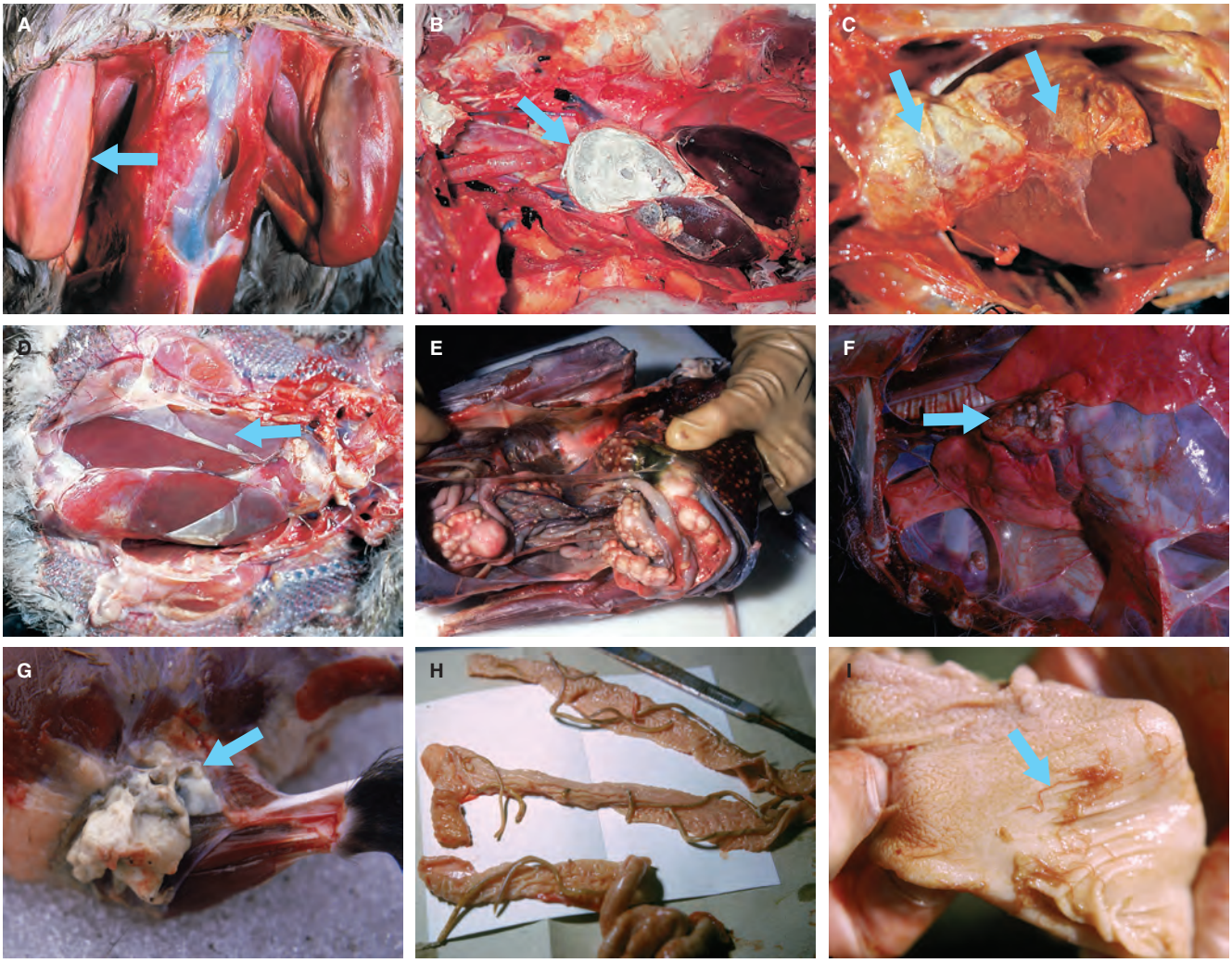


Photo A. James Runningen; B, Milton Friend; C, J. Christian Franson

Photo D, Milton Friend; E, James Runningen; F, Milton Friend

Photos G, H, and I by Milton Friend

Photo J by Milton Friend

Figure 5.8 Abnormal coloration, size, and shape of organs, the presence of growths within the body, and other indicators of disease are often readily seen when carcasses are opened. Examples include: (A) pale coloration of tissues, such as that caused by stress associated with improperly handling live animals (capture myopathy); (B) the accumulation of white, gritty deposits in the surface of organs, such as the heart of this bird due to dietary protein imbalances (visceral gout); (C) encasement of the heart and part of the liver by a fibrous covering in this bird, and (D) the translucent covering of the liver in another bird are the result of infection by the bacterium *Escherichia coli*. (E)The numerous, raised, firm nodules seen in this whooping crane are the result of avian tuberculosis. (F) The nodular area in the lung of this deer is a malignant tumor. (G) Abscesses, such as those in the leg of this muskrat, are sufficient reason to reject the use of meat from the carcass. (H) Parasites, such as these roundworms in the intestine of a raccoon, (I) stomach worms in a white-tailed deer, and (J) tapeworms in the intestine of this goose are commonly seen in wildlife carcasses. These parasites do not represent a state of disease and are not reasons to discard the carcass.

Table 5.3 Examples of parasite infections that may be observed in North American wildlife harvested for human consumption[a]

Disease/ parasite	Parasite type	Primary wildlife for occurrence	Observations	Human risks	Recommended action
Tracheal worm *Syngamus trachea*	Nematode (roundworm)	Upland game birds[b]	Large red worms in the trachea (Fig. 5.15)	None	Meat is edible
Gizzard worms *Amidostomum* spp.	Nematode	Upland game birds	Groups of small worms within the gizzard	None	Discard severely parasitized gizzards; thoroughly cook parts, if only lightly parasitized
Histomoniasis *Histomonas meleagris*	Protozoan	Upland game birds	Lesions only, parasite is microscopic; liver with discrete circular pale areas, ceca with necrotic debris (Fig. 5.17)	None	Discard liver; consumption of muscle tissue acceptable
Sarcosporidiosis *Sarcocystis* spp.	Protozoan	Waterfowl	Immature form of parasite that look like grains of rice in muscle tissue (Fig. 5.13)	None	Discard heavily infected tissue due to poor texture
Trichomoniasis *Trichomonas gallinae*	Protozoan	Doves, pigeons	Lesions only; parasite is microscopic; yellow cheese-like masses in mouth, throat, and crop (Fig. 5.16)	None	Meat is edible
Thorny-headed worms	Acanthocephalan	Waterbird, wild pigs, raccoons, turtles, fish	Nodules on the surface of the intestine and worms protruding through the intestine (Fig. 5.14)	None	Meat is edible
Dog tapeworm *Taenia pisiformes*	Cestode (tapeworm)	Rabbits	Bladder-like larval cysts free in the body cavity (Fig. 5.18)	None	Meat is edible; do not feed viscera to dogs or other canids
Myiasis	Warble and bot fly larvae	Rabbits, squirrels, caribou	Larvae imbedded in skin, muscle, or present in nasal passages (Fig. 5.10)	None[c]	Meat is edible after removal of areas of larval infestation
Larva migrans *Baylisascaris procyonis*	Nematode	Raccoon	Adult worms found within intestine (Fig. 5.8H)	Yes	Well-cooked meat can safely be eaten. However, need to avoid exposure to fecal material and intestinal tract contents because larvated eggs are infectious for humans if accidentally ingested
Mange *Sarcoptes scabiei; Notoedres douglasi*	Mites	Squirrels[d]	Major hair loss, crusted, thickened skin (Fig. 5.11)	Yes	Meat is edible but heavy infestations can result in secondary bacterial infections that preclude eating the meat. Avoid skin contact with carcasses as transient infections by *S. scabiei* possible
Demodectic mange *Demodex odocoilei*	Mite	Deer	Hair loss, thickened skin, pustules on skin	None	Same as other manges, but no risk for human infestation
Liver fluke *Fascioloides magna*	Trematode (Fluke)	Deer	See text (Fig. 5.19)	None	See text
Cysticercosis	Cestode	Moose	See text (Fig. 5.20)	None	See text
Ich *Ichthyophthirius multifiliis*	Ciliate	Fish	Readily seen, small white spots on skin, fins, gills	None	Heavily infected fish may have secondary infections and should be discarded; other fish are edible

Table 5.3 Examples of parasite infections that may be observed in North American wildlife harvested for human consumption[a]—Continued.

Disease/ parasite	Parasite type	Primary wildlife for occurrence	Observations	Human risks	Recommended action
Black spot/grub *Uvulifer ambloplitis*	Digenetic trematode (fluke)	Fish	Readily seen, small (pinhead size) black spots on skin, fins, and embedded in flesh	None	Fish are edible
White grub *Posthodiplostomum minimum* and others	Digenetic trematode	Fish	Small (1 mm or less) white spots in internal organs	None	Heavily infected fish may have secondary bacterial or fungal infections and should be discarded
Yellow grub *Clinostomum complanatum*	Digenetic trematode	Fish	Large (3 to 8 mm) nodules appearing under the skin and in the flesh	None	Parasites are highly visible after skinning the fish because of their yellow color and size; flesh should be thoroughly cooked or remove parasites prior to eating fish
Heterosporis *Heterosporis* spp.	Microsporidian	Fish	See text (Fig. 5.12)	None	See text

[a] Information provided is for wildlife species commonly eaten by humans. Some of these parasites also infect a wide range of other species. There are many parasites observed (some of which are pathogenic for humans) in other wildlife species that generally are not eaten by humans with access to commercial sources of food.

[b] Upland gamebirds = species such as wild turkey, grouse, pheasant, quail, and partridge.

[c] Humans can become infested by some species of fly larvae following the deposition of eggs on the human body by adult flies.

[d] Sarcoptic mange is most commonly seen in canids such as coyotes and foxes, species not commonly used by humans for food.

Ich or white spot is probably the most important freshwater fish parasite in the world; it is seen in the skin of many species of fishes in the temperate zone, but has no human health significance.[12] Heterosporis (*Heterosporis* spp.) is a newly identified parasite of fishes in the upper Midwest (USA) and in Canada that infects muscle tissue. Infected areas appear white and opaque (Fig. 5.12) and, in heavily infected fish, 90 percent or more of the body may consist of the parasite spores rather than muscle tissue. There is no evidence that humans can be infected by this parasite.[13] Other common fish parasites causing spot-like lesions are the grubs (digenetic trematodes or flukes) that infect warm-water fishes. The black grub (*Uvulifer ambloplitis*) causes black spot disease. The white grub (*Posthodiplostomum minimum*), which is found in internal organs, and the yellow grub (*Clinostomum complanatum*), which is found under the skin and embedded in flesh, are other spot-like diseases.[14] These parasites are not considered to be of human health importance (Table 5.3).

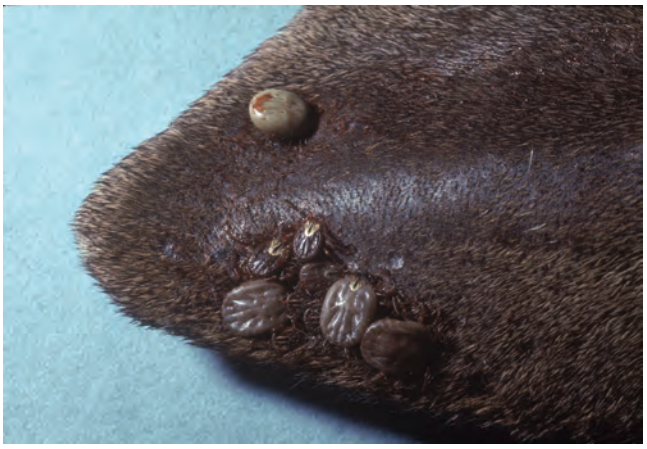


Photo by Milton Friend

Figure 5.9 Ticks are commonly found on both mammals and birds, and may vector a variety of diseases to humans. Therefore, precautions should be taken to avoid their transfer when handling wildlife carcasses. Self-inspection should follow the processing of carcasses when ticks are observed and prompt removal of any ticks found should be done in an appropriate manner (e.g., avoid crushing the tick and leaving their mouth parts imbedded in person's skin).

Internal Parasites

The most commonly seen and questioned internal parasites of wild game in North America are *Sarcocystis* spp. and acanthocephalans in birds, the **dog** tapeworm in cottontail rabbits, liver flukes in white-tailed deer, and **cysticercosis** in moose. Lesions caused by other parasites are commonly seen, but those parasites may be too small to be seen without magnification or are not readily visible because of their locations within the host (Table 5.3).

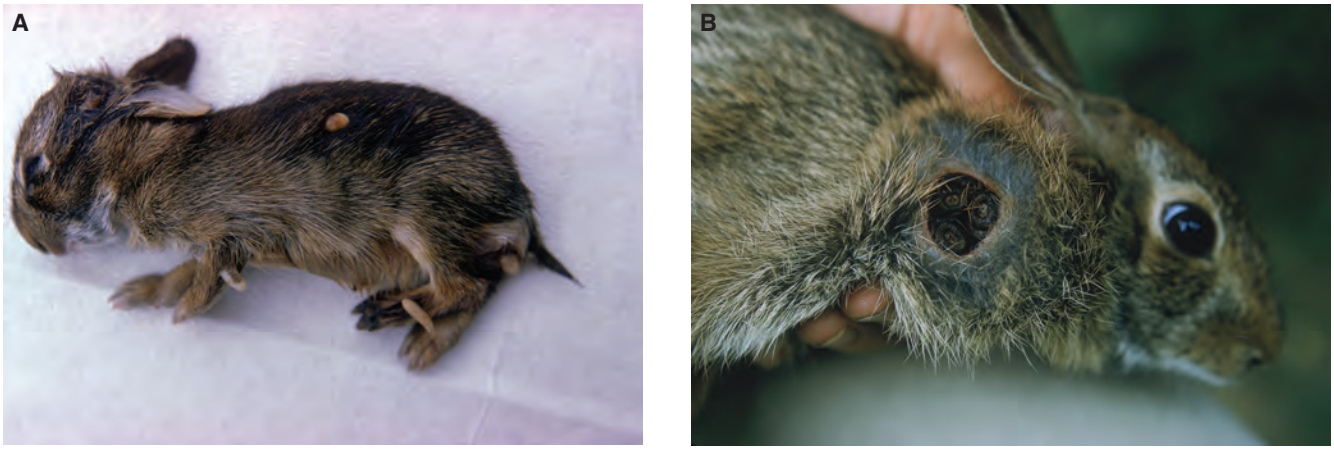


Figure 5.10 (A) Fly larvae embedded in the tissues of a nestling cottontail rabbit, and (B) more mature larval stages ("bots") embedded in an adult cottontail.

Sarcosporidiosis, or "rice breast" disease, is a common parasitic disease of some species of waterfowl and other wildlife; it is present under the skin rather than internally within the body.[15] The cysts formed in muscle tissue appear as rice-grain sized bodies, thus, the common name for this disease (Fig. 5.13). This highly visible protozoan infection does not constitute a public health threat, and properly cooked meat containing this parasite is safe to eat. Parasites of the Phylum Acanthocephala also are commonly seen in some species of birds (Fig. 5.14)[16] and mammals.[17] Their presence does not constitute a public health threat. Other common parasitic infections that may be seen in game birds include tracheal worms in pheasant (Fig. 5.15), trichomoniasis in **doves** (Fig. 5.16), and blackhead in turkey (Fig. 5.17).

Larvae of the dog tapeworm, *Taenia pisiformis*, are commonly encountered by rabbit hunters (Fig. 5.18), because rabbits are a primary intermediate host for this parasite. Humans are not infected. Hunters that feed the viscera from rabbits to their dogs may infect those dogs because, along with coyotes, foxes, and several other carnivores, dogs are definitive hosts for the parasite.[18]

Discovering the large American liver fluke, *Fascioloides magna*, within fibrous capsules in deer liver is often a startling finding for those unfamiliar with this parasite (Fig. 5.19).

Figure 5.11 Mange is a common disease of wildlife that affects numerous mammal species including the (A) gray squirrel, (B) red fox, and (C) wolf.

Photo courtesy of Karl Hayden, Fisheries and Applied Aquacultures, Auburn University, Alabama, USA

Figure 5.12 "Black grub" infection of *Heterosporis* spp. in muscle of largemouth bass.

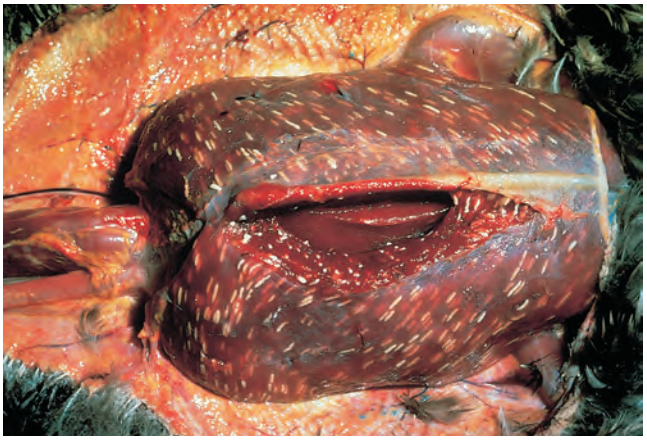


Photo by James Runningen

Figure 5.13 Cysts of *Sarcocystis* sp. in the breast muscle of a mallard duck.

These flukes occur in pairs or groups within those capsules and can be up to 8 cm long. There are no records of humans being infected by this parasite[19] and no reason for the meat of the animal to be discarded, even if the unpalatable appearance of an infected liver may cause rejection of that part of the animal as food.[20]

Cysticercosis due to infection by *Taenia ovis krabbei* is common in moose populations that are closely associated with wolves, the definitive host for this tapeworm. Parasite prevalence of 60 to 70 percent has been reported for some moose populations in Canada.[18,21,22] The larvae of this parasite encyst in skeletal muscles and in the connective tissue fascia in and between those tissues (Fig. 5.20). Heavy infections can result in significant tissue damage or loss of good body condition. Although human infections do not occur, reindeer meat infected with cysticerci is unacceptable for human consumption.[18] Despite the appearance of infected meat, heavily parasitized meat can be consumed without adverse effects on humans.[23]

Not all parasites of wildlife can be seen or easily detected and some of those that are "hidden" are pathogenic for humans. Hunters should be familiar with any disease activity in the areas where they hunt and know how to properly cook game meat to prevent exposure to parasitic diseases, such as trichinellosis and toxoplasmosis. Trichinellosis in humans is caused by ingestion of the nematode *Trichinella*

Photo by J. Christian Franson

Photo by James Runningen

Photo by Rebecca A. Cole

Figure 5.14 (A) Large numbers of acanthocephalan parasites may be seen protruding from the intestine of some birds; (B) these parasites attach to the inner surface of the intestine. Severe infections by some species, such as in this sea otter (C), may be pathogenic for the animal.

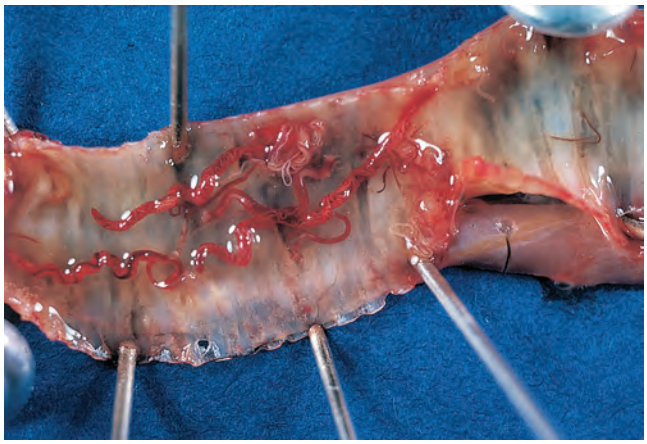


Photo by Milton Friend

Figure 5.15 Tracheal, or gapeworm infection of a ring-necked pheasant. This parasite does not infect humans.

Photo by J. Christian Franson

Figure 5.16 Trichomoniasis is the cause of the yellow, cheesy-like growths in the esophagus of this mourning dove.

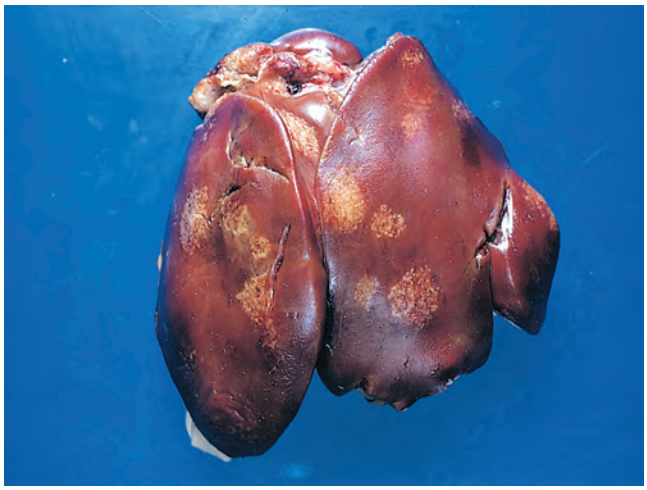


Photo by Milton Friend

Figure 5.17 The pale areas within the liver of this partridge are due to histomoniasis, or blackhead.

spp. (primarily *T. spiralis*) that are encysted in striated muscle tissue of infected animals, such as wild swine and carnivores (e.g., bears). Natural infections occur in many different species of wildlife, including predatory birds.[24] Since infection is not readily detectable, except by laboratory methods, it is important to thoroughly cook the meat from wild game commonly associated with this disease.[25] Recent cases of trichinellosis involving jerky made from cougar meat serves as an example of the consequences of inadequate food preparation (see Chapter 2).

Toxoplasmosis (*Toxoplasma gondii*) is a common and sometimes serious infection of humans. Infections most commonly occur by ingestion of cysts in infected meat and by oocysts (infective eggs) in food and water that have been contaminated by **cat** feces. Many species of wildlife and domestic animals are naturally infected with *T. gondii*. To prevent exposure, wild game meat should not be consumed raw. Meat from any animal should be cooked to 150° F prior to consumption, meat should not be tasted while cooking, nor should homemade game sausages be tasted during seasoning. Cooking destroys encysted organisms, and thorough hand washing removes surface contamination and should follow any handling of raw game meat.

A variety of nematodes (roundworms) and cestodes (tapeworms) may be encountered when cleaning fish. Most of these are harmless if accidentally ingested,[12] but several, such as the cod worm, *Phocanema decipiens*, have caused human cases of disease (see Chapter 2). *Eustrongylides* spp., a nematode that causes massive bird mortalities (Fig. 5.21),[26] also has been the cause of several human cases of serious disease.[12] *Diphyllobothrium latum* and other species within this genera commonly infect humans when fish are eaten raw.[49] Thoroughly cooking fish eliminates any hazards from parasites that may be present.

Bacteria

Although most wildlife harvested do not have bacterial diseases of significance for humans, exceptions do occur (Table 5.4). Like other species, wildlife are subject to a wide variety of bacterial infections. Some are primary infections, such as avian cholera (*Pasteurella multocida*) and tularemia (*Francisella tularensis*), while others involve secondary invasion of wounds and other debilitating processes. Types of diseases encountered will vary with the species harvested and geographic area. However, humans are unlikely to harvest wildlife affected with diseases that kill rapidly, such as anthrax and avian cholera. Therefore, unless animals found dead are being processed for food, there should be little concern about those types of diseases when consuming personally harvested game meat. Also, the majority of bacterial diseases present, result in significant (but not diagnostic) lesions in infected animals, thereby providing visible evidence of disease, even to the "untrained eye" (Fig. 5.22). Because unapparent infections can occur and intestinal contents may

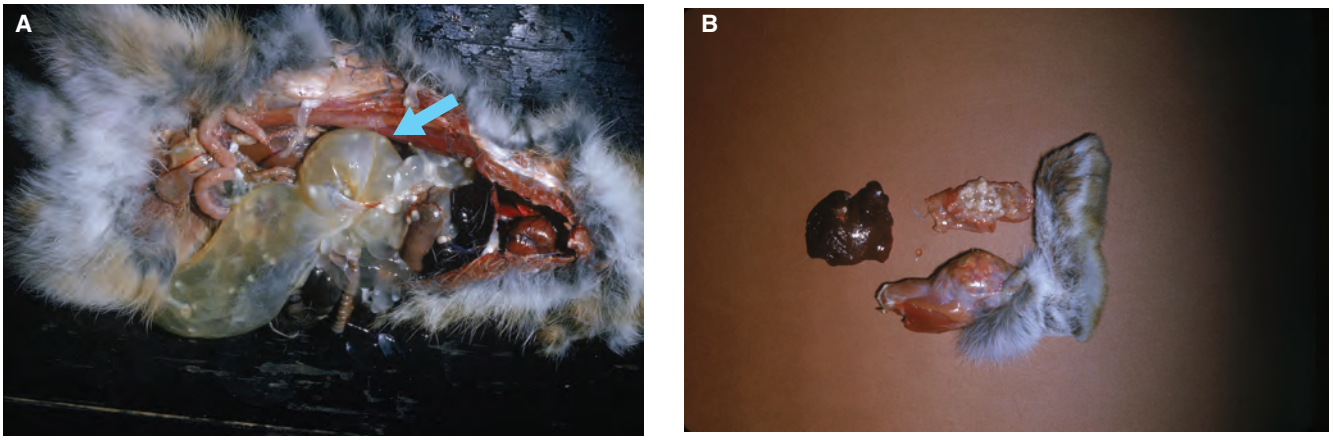


Figure 5.18 The bladder-like structure (arrow) in the body cavity of this cottontail rabbit contains large numbers of cysticerci (larvae) of the dog tapeworm. These larvae have also been found encysted in other parts of the body, (B) such as within the fascia of the leg of this snowshoe rabbit and in its liver.

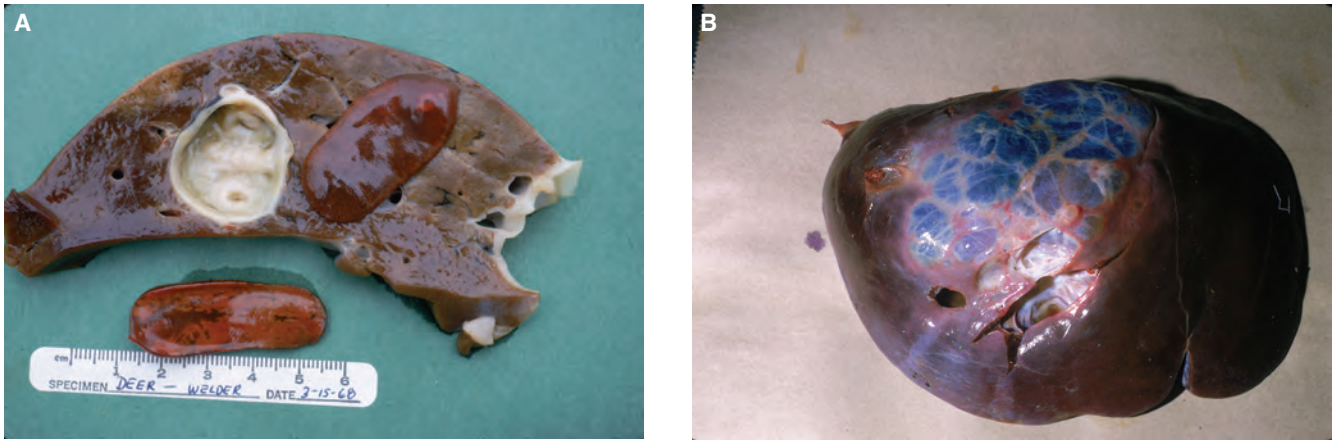


Figure 5.19 (A) The large American liver fluke is a common parasite of white-tailed deer in some regions of the USA. (B) Tissue damage to this organ can be extensive.

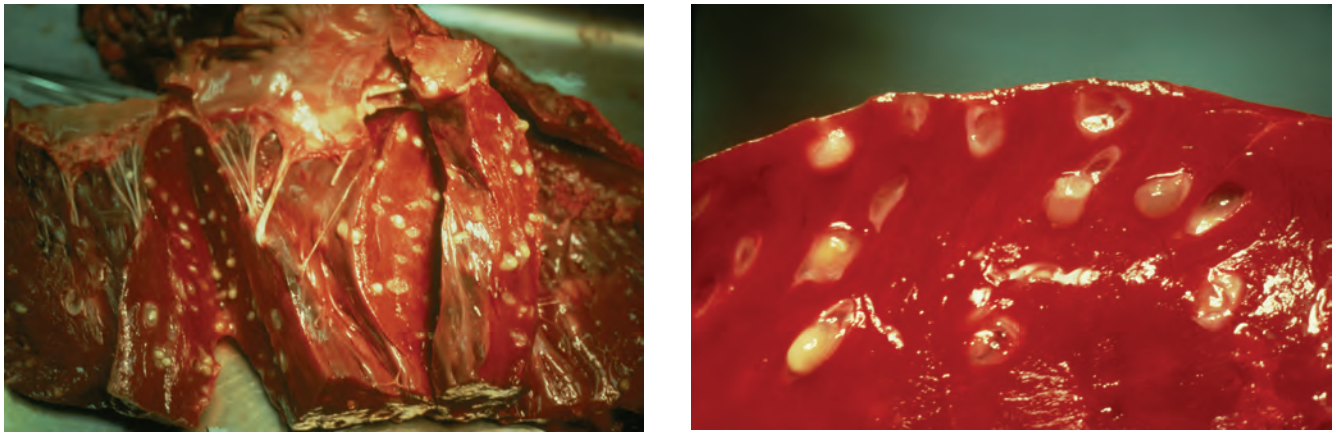


Figure 5.20 Larval forms of the tapeworm *Taenia ovis krabbei* are commonly found encysted in the muscle tissue of moose.

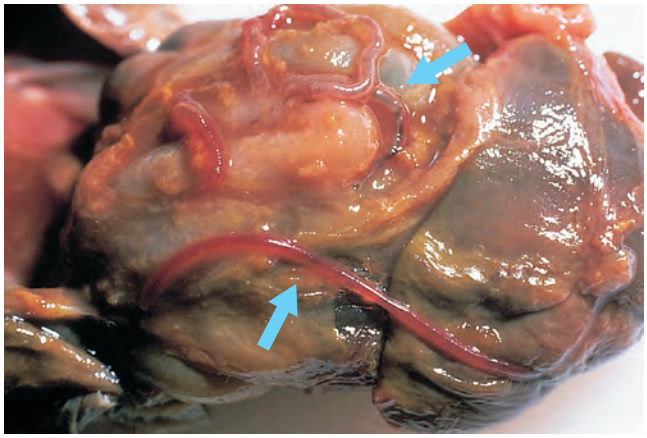


Photo by J. Christian Franson

Figure 5.21 The roundworm *Eustrongylides* sp. and the raised tunnels (arrows) it causes within the intestine are seen in this snowy egret.

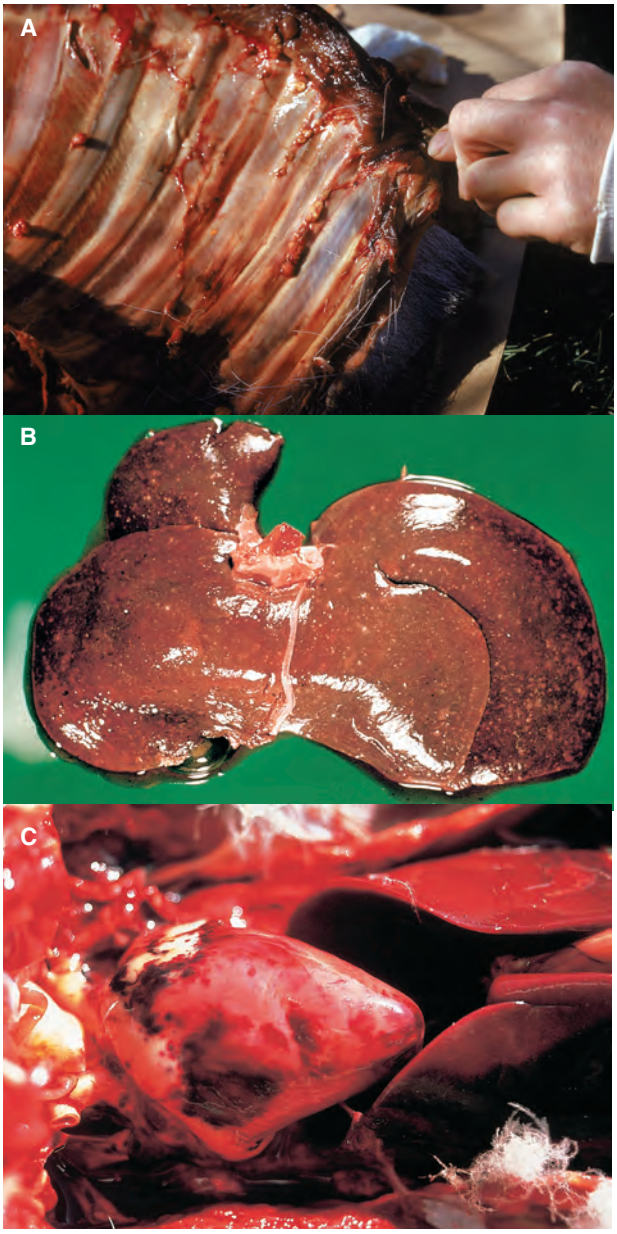
contain *Salmonella* and other enteric pathogens, when processing game meat, it is important to avoid contamination of meat by fecal material. In general, the presence of lesions on internal organs suspected to be caused by infectious bacterial diseases is reason to discard the carcass.

Brain abscesses are occasionally found by deer hunters, but these lesions do not pose a health threat for humans and should not result in disposal of the carcass. These abscesses are thought to result from invasion by skin-inhabiting bacteria. They are much more prevalent in males than females, often are associated with the antler pedicel, and generally occur following velvet shedding to shortly after the antlers are shed.[20] Brain tissue from infected animals should be discarded. Even if not infected, brain should no longer be utilized in any foods because of the emergence of chronic wasting disease (see *Prions*, this chapter).

Viruses

Wildlife are affected by a broad spectrum of viral diseases. However, in North America few of these diseases are likely to be encountered by people harvesting wildlife for food. Many of these diseases primarily occur in species not typically eaten by most people (e.g., small rodents) or the disease has caused severe illness or death that makes the harvest of infected animals unlikely.

Viral diseases that cause external tumors typically occur infrequently, seldom are lethal, and are readily observed. Cutaneous fibromas of deer are hairless tumors that hang from the skin and generally are of no significance for the animal unless their location interferes with sight or feeding (Fig. 5.23). These papillomas pose no health hazards for humans and the meat from these animals is suitable for consumption. Aggregations of tumors, or especially large tumors, often become abraded, which then can allow infection by bacteria and fungi. These animals should not be eaten.



A. Photo by Milton Friend

B. Photo by James Runningen

C. Photo by Milton Friend

Figure 5.22 Examples of visible evidence of infectious disease associated with some bacterial diseases of wildlife are: (A) nodules along the rib cage of this white-tailed deer with bovine tuberculosis; (B) numerous, small, yellow and white spots on the liver of this beaver that died from tularemia; and (C) hemorrhages on the heart of a goose that died from avian cholera.

Table 5.4 Examples of potential bacterial infections in North American wildlife commonly harvested for human consumption[a]

Disease	Pathogen	Primary wildlife for occurrence	Observations	Human risks	Recommended action
Brucellosis	*Brucella* spp.	Bison, elk, caribou, feral swine	Enlarged reproductive organs, enlarged leg joints, retained placental materials	Yes	Wear protective gloves when processing carcass, minimize contact with reproductive organs, do not open enlarged joints or areas of fluids that may be encountered within the carcass, and cook meat thoroughly.[46]
Brain abscessation	*Actinomyces* spp., *Staphylococcus* spp., *Streptococcus* spp.	Deer	Abscess within the brain, pus at antler base	Yes	Meat of animal is safe, prevent contact with abscesses and contamination of carcass. Wear protective gloves when removing antlers for trophy use; discard gloves along with head and replace with new gloves if further handling/processing of animal is to occur.
Dermatophilosis	*Dermatophilus congolesis*	Numerous; deer to rabbits	Major thickening of areas of the skin with pustular, scabby lesions and associated hair loss	Yes	Prevent contact with infected areas of skin; self-limiting focal infections can occur in humans and more severe infections may occur in immunocompromised people.[47] Meat from animal is safe to eat.
Tuberculosis	*Mycobacterium bovis*	Deer, elk, bison	Nodules containing cheesy-like material or granular-like substances within lymph nodes, organs, and along the internal surface of the rib area (Fig. 5.22A)	Yes	Properly discard infected animals and notify authorities of findings. Meat from animal should not be consumed.
Avian tuberculosis	*M. avium*	Birds	Masses of nodules within major organs and/or along intestines (Figs. 5.5G and 5.8E)	Yes	Same as for mammalian tuberculosis.
Tularemia	*Francisella tularensis*	Rabbits, beaver, muskrat	Pale spots scattered within the liver and spleen (Fig. 5.22B)	Yes	Thoroughly cook meat to be eaten, wear protective gloves when handling carcasses, and prevent transfer of ticks and other biting arthropods.
Furunculosis	*Aeromonas salmonicida*	Trout[b], salmon	Ulcers on skin[c] and in muscle tissue; organ haemorrhages	No	Discard carcass, consumption not recommended.

[a] Information provided is for wildlife species commonly eaten by humans. Some of these bacteria also infect a wide range of other species. There are many bacteria observed (some of which are pathogenic for humans) in other wildlife species that generally are not eaten by humans with access to commercial sources of food.

[b] Now recognized that many species of fish are infected by *A. salmonicida*.[48]

[c] Classical disease produces boil-like lesions on skin and in muscle tissue; pathology varies widely with age of fish, type of disease caused, and whether typical or atypical *A. salmonicida* infections are involved. [48]

Photo by Milton Friend

Figure 5.23 A white-tailed deer with multiple cutaneous fibromas.

Photo by Milton Friend

Figure 5.24 Fibromas on gray squirrels collected from a city park.

Photo by Thomas Yuill

Figure 5.25 Shope's fibroma on the foot of a rabbit.

Fibromas of viral origin also occur in the gray squirrel (Fig. 5.24). There is no known human health hazards associated with these tumors or any of the other papillomas found on wildlife throughout the world, with the possible exception of those from nonhuman primates.[27] Within the USA, Shope's fibroma (Fig. 5.25), a poxvirus infection of cottontail rabbits, is perhaps the most common tumor-like disease seen in wildlife. As for the papillomavirus, this fibroma generally is of little consequence for infected animals and has no human health implications.[28] Poxvirus infections also occur in birds (Fig. 5.26), sometimes resulting in death because of impaired vision and inability to feed. Here again, there are no known human health risks associated with these viruses.[29]

Hemorrhagic disease is another malady hunters may encounter in wild ruminants such as deer and **antelope** (Fig. 27). Epizootic hemorrhagic disease (EHD) viruses and bluetongue (BT) viruses are the causative agents. Epizootics of EHD and BT periodically kill large numbers of wildlife, but the viruses involved are not infectious for humans.[20]

Prions

Prion diseases continue to be a relatively little understood yet heavily studied group of emerging infectious diseases. They include scrapie, a long existing sheep disease; bovine spongiform encephalopathy (BSE) of cattle; Creutzfeld-Jacob disease (CJD) and kuru of humans; a variant CJD (vCJD) associated with BSE that causes disease in humans; mink spongiform encephalopathy; and most recently chronic wasting disease (CWD) of deer and elk.[30,31]

CWD is of great concern to hunters and game ranchers as it is ultimately fatal and affects several deer species (Fig. 5.28). Unlike the vCJD associated with BSE, no link has been found between CWD and disease in humans. However, because there are many unanswered questions about CWD,

Photo by James Runningen.

Figure 5.26 A bald eagle with an extreme avian pox infection leading to its death because of an inability to feed.

health officials advise against consuming meat from animals known to be infected with CWD. In addition, hunters should wear disposable gloves when field dressing deer or elk taken in areas where this disease is found and when deboning meat. The purpose for deboning is to remove associated neural tissue, the consumption of which is considered to be the primary pathway for exposure to prions. A separate knife, not the one used to butcher the deer, should be used to sever the spinal cord when the head is removed. This precaution avoids contamination of the primary butcher knife by nerve tissue that may contain the disease agent if the animal was infected. Also, avoid handling and consuming brain, spinal cord, lymph nodes, eyes, tonsils, and spleen when processing deer and elk from areas where CWD is known to be present.[30–32] Complete instructions on handling, testing, and disposing of deer and elk carcasses can be obtained from the Department of Natural Resources in the state where the deer or elk are to be harvested. Observations of deer or elk with the appearance of CWD should be reported to that agency.

Fungi

Wildlife may either become infected by fungal organisms, such as *Aspergillus* spp. (Fig. 29), or they may be affected by toxins produced by fungi (e.g., mycotoxins). Aspergillosis is the most common fungal disease likely to be seen in birds and is likely to be highly visible. Typically, infected birds have yellow plaque-like lesions that have a cheesy appearance and consistency and are found in the lungs and airsacs. Lesions similar to bread mold also may be present.[33] Severely infected birds often are very thin and are likely to be discarded on this

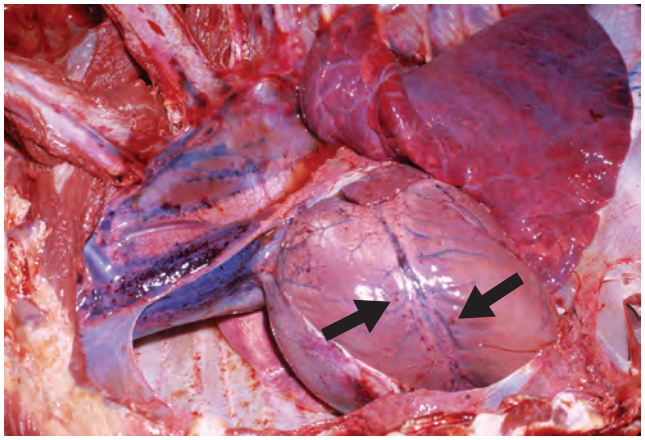
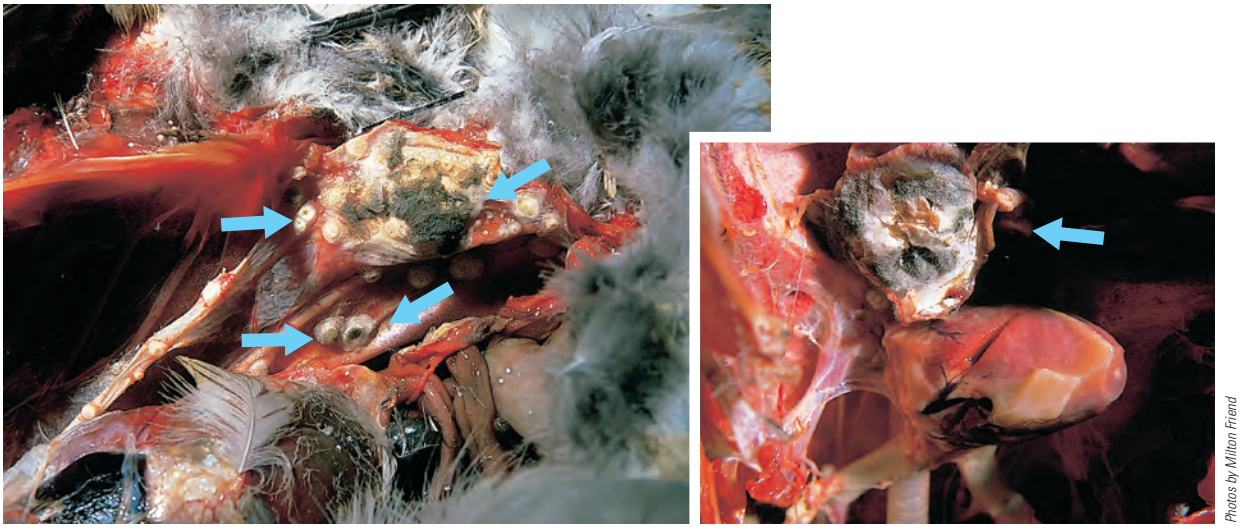


Photo by Milton Friend

Figure 5.27 Hemorrhages in the tissues and organs, such as in this white-tailed deer, are common findings in deer and antelope dying from epizootic hemorrhagic disease and bluetongue.

Photo courtesy of Christina Sigurdson, Colorado State University

Figure 5.28 Clinical signs and the unthrifty appearance of animals, rather than internal pathology, are indications of the potential that a deer or other cervid is infected with chronic wasting disease. Testing of appropriate tissue is required for a diagnosis.



Photos by Milton Friend

Figure 5.29 The presence of "cheesy" plagues and the "bread mold" present on the surface of tissues within this Canada goose is indicative of the fungal disease aspergillosis.

basis. The potential for human infection resulting from exposure to fungi present in the carcass is very low and properly cooked meat would be safe to eat. Nevertheless, consumption of these carcasses is not recommended.

Individuals harvesting mammalian wildlife may encounter superficial (skin) fungi that may or may not be involved with skin lesions that appear as discrete round areas of scaling, crusting, and hair loss. Typically, these lesions appear on the head and back, may result in depigmentation and a thickening of the skin in areas of infection. These infections are commonly referred to as ringworm or tinea and, medically, as dermatophytosis. Several genera of fungi are involved. *Microsporum* spp. and *Trichophyton* spp. are the most likely to be transmissible from animal to humans.[34] Meat from infected carcasses poses no known human health risks. Human exposure is prevented by wearing protective gloves when handling carcasses and hides.

Toxins

Wildlife may be exposed to a wide variety of toxins in addition to infectious agents. These toxins may be of natural (e.g., microbial) or synthetic (e.g., pesticides) origin. Rarely will the carcass reveal any obvious signs that the animal had been exposed to these toxins. Therefore, coverage of these types of agents is beyond the scope for this chapter. Birds clinically ill from diseases, such as avian botulism and aflatoxicosis (Fig. 5.30), may be seen in the field because the time between intoxication and death often extends for several days.[35] Those concerned about natural and synthetic toxins should avoid consuming wildlife that appear to be excessively thin and, prior to harvesting wildlife, check with the state Department of Natural Resources to determine if any health advisories have been issued.

Should I Eat This?

"The discovery of a new dish does more for human happiness than the discovery of a new star." (Brillat-Savarin)[36]

The type of food eaten is a personal choice. The popularity and high nutritional value of finfish and shellfish are reflected in the rapid growth of aquaculture during recent years, because wild stocks can no longer meet the demands for those food items. Greater demands for venison, bison, and other wildlife meats have resulted in substantial increases in the captive-rearing of various wildlife as alternatives for domestic species whose meat has higher fat and cholesterol content (see Chapter 3, Fig. 3.18). From a human nutritional perspective, wildlife often are a better choice than livestock and poultry.

Within the USA, most game meat consumed is from free-ranging rather than ranched wildlife. Emergence and reemergence of infectious diseases in wildlife and other species (see Chapters 2 and 3) continues to result in new diseases of concern. Some of these, like bovine tuberculosis (*Mycobacterium bovis*) are old diseases that have gained new prominence.[37] Therefore, hunters and game consumers within the USA need to be informed about diseases affecting wildlife in areas where harvests are being considered because major differences in risks are associated with inspection processes for commercial meats versus individuals handling and processing their own game meat.

Because free-living wildlife do not receive preemptive human intervention to combat disease (e.g., antibiotics in feed, vaccines, etc.), there is a high probability that vertebrates infected by significant pathogens will die before they are harvested. Therefore, at least within North America, there is little reason to consider properly handled and prepared game meat to be of greater risk as a source for disease than domestic meat. Nevertheless, local exceptions involving chronic diseases, such as bovine tuberculosis, may exist. Therefore, general knowledge of the health status of wildlife in the area of harvest is important. This knowledge constitutes informal health advisories and is helpful in making informed choices about what one chooses to eat and how to prepare it. Similar judgments are made in response to formal health advisories issued for domestic foods and advisories issued for environmental contaminants that may be present in fish and other foods harvested from aquatic environments.

Common sense should always be a factor in what one eats and does not eat, regardless of the source of the food item. Game meat is a staple food item for many people throughout the world, a gourmet food for some people, and for most people, food that is greatly enjoyed. Bon appétit.

Pauline Nol and Milton Friend

Photo by Ronald Windingstad

Figure 5.30 In general, wildlife with abnormal behavior and appearance, such as this sandhill crane affected by a fungal toxin, should not be harvested for human consumption.

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