Campylobacteriosis: Importance

• *C. jejuni* has been implicated as a cause of diarrhea in adult and immature primates including
cynomolgus monkeys (*Macaca fascicularis*)

• Patas monkeys (*Erythrocebus patas*).

• It is most severe in infants, children and pre-pubertal primates.

• Infection is usually via fecal/oral route. Long term shedding has been documented in non-human primates.
• A high prevalence of infection (70%) has been reported from several primate centers.

• For instance, *Campylobacter* were detected by PCR in feces of monkeys of different species (clinically healthy, with diarrhea, and dead from acute enteric infections) (Kalashnikova et al., 2002). The incidence of *C. jejuni* DNA in monkeys with acute enteric infections was higher than in healthy animals (69.6 and 51.3%, respectively). The highest percentage (92.3) of positive results was observed in *Macaca mulatta* with enteric diseases and in dead macaques.

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• A raising problem is human infection of endangered wildlife, especially mountain gorillas, which can be exposed to human pathogens.

• 62 fecal specimens collected from mountain gorillas in Uganda, were tested for *Campylobacter* spp., *Salmonella* spp., and *Shigella* spp., with an overall prevalence of infection of 19%, 13%, and 6%, respectively (Nizeyi et al., 2001).

• Most of the enteropathogens (80%), and all *Shigella* spp. organisms were isolated from subadults and adult gorillas.

• The prevalence of *Campylobacter* spp. and *Salmonella* spp. infections among human-habituated gorillas has doubled during the last 4 years.
Campylobacteriosis: Clinical features

- The incubation period is from 2 to 5 days.

- Diarrhea, with or without blood and leukocytes, abdominal pain, and constitutional symptoms, especially fever, are routinely noted. The severity of the illness can be variable but in most cases, it is brief (7 to 10 days) and self-limiting. In humans, the disease is common in developing countries. The disease affects all age groups.

- Clinically, the disease in monkeys is similar to that seen in humans. It is characterized by a hemorrhagic, watery diarrhea that affects the jejunum, ileum and colon. The chronic recurrent and carrier state of the organism in monkeys is similar to that reported in humans.

Campylobacteriosis: Zoonotic aspect

- In a laboratory animal setting, a technician developed Campylobacter enteritis after performing husbandry chores on recently imported nonhuman primates shedding the organism in their feces (Tribe et al, 1979).

- However, there are several serotypes of Campylobacter. Development of a reliable serotyping system will allow better understanding of the role that animal hosts play in the epidemiology of campylobacter infection in humans.

- In a recent study in various research institutions, nine different serotypes were identified in nonhuman primates. Surveys performed in countries where indigenous nonhuman primates are captured and later sold for research have documented variable incidences of human Campylobacter enteritis.
**Campylobacteriosis: Treatment**

- Erythromycin and tetracycline appear to be highly effective against clinical signs, but they do not eliminate the organism from the animal.

- Prototype oral *Campylobacter* killed whole-cell vaccines with or without oral adjuvant were tested for safety and immunogenicity in rhesus monkeys (Bagar et al., 1995).

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**Yersiniosis: *Y. pseudotuberculosis* and *Y. enterocolitica***

- Pseudotuberculosis (*Y. pseudotuberculosis*) is a common disease in zoo animals, especially in monkeys. Infection usually by oral route, by consumption of contaminated food from rodent or bird dejections.
- 3.5 to 11.6% antibody prevalence for *Y. pseudotuberculosis* in macaques from Japan or imported from the Philippines and kept in Japanese research institutions.

- Yersiniosis caused by *Y. enterocolitica* has been reported quite often from nonhuman primates kept in zoos or research facilities. In primates, quite a number of infections were caused by serotype 3,9 or 5,27, the most frequent human pathogens.
Yersiniosis: Clinical course

• In human beings, most people will develop a subclinical infection. In young males and aged or debilitated persons, disease is more frequent.

• Clinical pseudotuberculosis in man appears as: pseudo-appendicitis, erythema nodosum, polyarthritis, septicemia.

• No human cases have been directly related to primate infection.

Yersiniosis: Clinical course

• In nonhuman primates, pseudotuberculosis may appear as a sporadic disease, but it is often enzootic, sometimes with mortality rates of more than 10% of animals at risk. The evolution of pseudotuberculosis in simian primates usually follows an insidious course without pathognomonic symptoms. In monkeys, gastroenteritis is the most common lesion (acute ulcerative enterocolitis).

• The animal are either found dead or suffer from only nonspecific symptoms such as weakness, depression, watery or hemorrhagic diarrhea, dehydration, fever or hypothermia, hyponatremia and hypochloremia, especially when infected by Y. enterocolitica. Increased abortion and stillborn rates have been observed during outbreaks in Java macaques and squirrel monkeys.
Yersiniosis: Lesions in NHP

Multifocal miliary necrotic foci also develop in the spleen and liver.

Yersiniosis: Treatment

Y. pseudotuberculosis: Treatment can be implemented by using tetracycline or neomycin.

Y. enterocolitica responds satisfactorily to tetracycline, chloramphenicol, neomycin, gentamycin and streptomycin.

Brucellosis

In very rare cases evidence of Brucella infections have been found in non-human primates. In the late 1960s few cases were reported from baboons in Kenya. However, concern about cross-reactivity with Bordetella bronchiseptica have been reported.

Experimentally inoculated monkeys (macaques) will develop focal granulomatous lesions in several organs (Brack, 1987).
Tularemia

- Tularemia is a zoonotic infection that has been reported in more than 50 species of mammals, birds, and reptiles in North America. Lagomorphs and rodents act as reservoirs of *Francisella tularensis*.

- Evidence of the disease has not been found in free-living non-human primates. Isolation of *F. tularensis* from the brain of a naturally infected pet squirrel monkey (*Saimiri sciureus*) was reported by Emmons in 1970 in California.
- In 1975, tularemia was confirmed in a dead Geoffroy's marmoset (*Callithrix geoffroyi*) in a California Zoo. In 1978, four of nine *Saguinus nigriceps* monkeys in a Canadian zoologic garden in the summer 1978 from tularemia.

Tularemia

- The clinical disease in experimentally infected monkeys is very similar to that in man, but mortality is usually higher.

- Lesions observed in the few natural cases and in experimentally infected monkeys consisted of splenomegaly, enlargement of mesenteric lymph nodes, slight hemorrhage into the intestines, and a fibrinous peritoneal exudate. Small white spots in the spleen and liver were foci of caseous necrosis.

- Infected ground squirrels and their fleas might have been the source of monkey infection. It is highly probable that transmission occurred via the fleas that were on the squirrels. No human infection has been reported from infected monkeys.
Melioidosis

• Caused by the bacterium Burkholderia (Pseudomonas) pseudomallei, an environmental saprophyte which is readily isolated from soil and water in endemic areas.

• Infection, which is thought to occur by inoculation, inhalation or ingestion of environmental organisms has been reported in human beings and a wide range of other animal species. The majority of cases have arisen in Southeast Asia and northern Australia.

• There have been several reports of melioidosis in captive primates in Malaysia, Australia and the USA. In 1990, an outbreak of melioidosis was identified in a batch of feral cynomolgus monkeys imported to Britain from the Philippines. Thirteen confirmed or possible cases occurred among a batch of 50 animals.

Melioidosis

• The majority of the affected monkeys had splenic and/or hepatic abscesses, and infections of the soft tissues and skin were also frequently observed. The lungs which are the commonest foci of localized melioidosis in human beings were not involved, although they have been involved in several previous cases of melioidosis among primates.

• Clinical manifestations are extremely varied. Most of the infected animals had no clinical signs despite extensive abscesses. Some monkeys were lethargic or had cutaneous abscesses or died suddenly.

• No human cases have been reported transmitted by non-human primates.
LEPTOSPIROSIS

• Although experimental leptospirosis has been studied in various species of non-human primates, the occurrence of naturally acquired acute disease in monkeys is uncommon.

• Only sporadic clinical cases have been reported in chimpanzees used for biological experimentation, and in barbary apes (*Macaca sylvana*) maintained in a zoo. Until the outbreak at the Pasteur Institute in French Guyana, no cases of leptospirosis had been reported in New World monkeys.

• In Old world monkeys inoculated with leptospira organisms, rhesus, patas and vervet had clinical symptoms as well as squirrel monkeys: inappetence, fever, jaundice, convulsions and death.

LEPTOSPIROSIS

• In an extensive serosurvey on 1,420 monkeys, 7.9% of the Old World monkeys had leptospiral agglutinins and only one of 74 New World monkey (Minette, 1966).

• In Asai et al. (1991) study, a seroprevalence of 2.9% was reported from macaques kept in Japanese institutions.

• Lesions included minimal hemorrhages in the lungs, heart, small intestine and colon.

• Among 109 squirrel monkeys at the Pasteur Institute, French Guyana, 11 monkeys had an acute illness, with jaundice and a hemorrhagic syndrome, leading to 10 deaths. 5 pregnant females aborted and a serosurvey indicated that 26% of the monkeys had antibodies. The contamination of the breeding colony may be related to the presence of infected rodents inside and around the reproduction park.
KLEBSIELLOSIS

• *Klebsiella pneumoniae* is an important pathogen in monkeys, especially New World monkeys that have a lowered resistance.

• Among newly arrived, wild caught *Saguinus*, the organism was isolated from the throats of 64% and was associated with pneumonia, septicemia, and enteritis. Most common symptoms are coughing, sneezing, nasal discharge, dyspnea, anorexia.

• Treatment is effective with kanamycin, streptomycin, colimycin or gentacin. Monkeys usually get infected by contact to humans.

EHRLICHIOSIS

• An outbreak of ehrlichiosis caused by *E. chaffeensis* occurred in a lemur colony in Durham, N.C. (Williams et al., 2002).

• Anorexia, fever, lethargy, and lymphadenopathy developed in seven ring-tailed lemurs (*Lemur catta*) and one red ruffed lemur (*Varecia variegata rubra*), ranging in age from 14 months to 17 years. *Amblyomma americanum, Rhipicephalus sanguineus*, and *Dermacentor variabilis* adult ticks were found on lemurs at the time of illness.
EHRLICHIOSIS

An unanticipated series of events created the opportunity for an epizootic of *E. chaffeensis* infection involving lemurs:

In association with winter fence maintenance and construction, the inadvertent introduction of several white-tailed deer into the lemur’s 22-acre summer enclosure facilitated the transport of ticks onto the facility.

BARTONELLOSIS

• A case of bacteremia caused by *Bartonella quintana* has been recently identified in a NHP colony in the eastern USA (Breitschwerdt, personal communication)