

NHP Secondary Species: Marmosets, tamarins, owl monkeys, squirrel monkeys, and baboons

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Disclaimers

- This is NOT an ACLAM sanctioned presentation
- All information is deemed reliable and correct, but no guarantees on accuracy
- No presented information is known to be specifically included in the ACLAM certification exam

A little perspective....

- Of the ACLAM exam questions that require knowledge of a specific species to answer correctly:
 - Primary species: 60-70%
 - **Secondary species: 18-28%**
 - Tertiary species: 7-17%
- Nonhuman Primate specific references:
 - Laboratory Animal Medicine, 2nd edition. American College of Laboratory Animal Medicine, eds. Fox, Anderson, Lowe, Quimby. Academic Press, 2002.
 - Nonhuman Primates in Biomedical Research Biology and Management. American College of Laboratory Animal Medicine, eds. B. Taylor Bennett, Christian R. Abee, Roy Henrickson. Academic Press, 1998.
 - Nonhuman Primates in Biomedical Research: Diseases. American College of Laboratory Animal Medicine, eds. B. Taylor Bennett, Christian R. Abee, Roy Henrickson. Academic Press, 1998.

→ New editions hot off the press!

Species

- Give the genus and species for each



Saguinus oedipus (cotton top tamarin)



Saguinus mystax (mustached tamarin)



Papio hamadryas (baboon)



Saimiri sciureus (squirrel monkey)

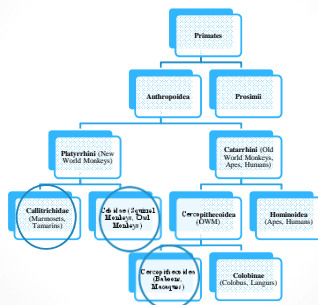


Callithrix jacchus (common marmoset)



Aotus nancyanae (owl monkey)

Taxonomy



| Platyrrhine | Catarrhine |
|---|---|
| South and Central America | Africa and Asia |
| Flattened muzzle, broad spaced laterally flared nares | Elongated muzzle, narrowly spaced downward facing nares |
| May have prehensile or pseudoprehensile tails | No prehensile tails (apes do not have a tail) |
| Arboreal | Terrestrial (mostly) |
| Require D3 in diet, cannot utilize D2 | Do not require D3 in diet, can utilize D2 |
| Estrus cycle | Menstrual cycle |
| Diurnal (except owl monkey) | Diurnal |
| Hemochorial placenta | Hemochorial placenta |
| No cheek pouches | Cercopithecidae have cheek pouches |
| No ischial callouses or sex skin | May have ischial callouses and sex skin |
| Do not have opposable thumbs | All have opposable thumbs |
| 2.1.3.2 or 2.1.3.3 dental formula | 2.1.2.3 dental formula |

Broad-nosed, laterally flattened nares

Elongated nose, downward facing nares

<http://zooanimals.tumblr.com>
<http://tshwined.org/primate-research-centre/primates/baboons>

- Most common NWM species used in research: common marmoset, cotton-top tamarin, owl monkey, squirrel monkey
 - Advantages: reduced cost, shorter generation, ease of handling
 - Disadvantages: more remotely related to humans, restricted availability

Unique to Callitrichids

- Smaller body size
- Fewer teeth (32 vs. 36 in other NWMs) and specialized lower dentition in marmosets
- Flat nail on big toe, claw-like nails on other digits (tegulae)
- High rate of non-identical twinning, permanent chimeras
- Cutaneous chest or perineal scent glands
- Non-prehensile tail

Callitrichids (marmosets and tamarins)

- Smallest NWMs, resemble each other
 - *Callithrix jacchus* and *Saguinus oedipus* are most commonly used in research
- Anatomy
 - No sexual dimorphism
 - Marmosets
 - 300-500g
 - 7-7.5 inches tall
 - Lifespan : 12 years (wild), 15 years (captivity)
 - Tamarins
 - 400-600g
 - 8-9 inches tall
 - Lifespan 13.5 years (wild), up to 25 years (captivity)
 - Dental anatomy
 - Marmosets: V-shaped mandible with enlarged, chiseled lower incisors and short canines (for tree gum diet)
 - Tamarins: U-shaped mandible with short incisors, long canines

Callitrichids

- Habitat
 - Entirely arboreal, territorial
 - Common marmoset
 - Brazil
 - Disturbed forest or edge habitat
 - Cotton-top tamarin
 - Columbia
 - Primary or secondary forest
- Diet
 - Insects, fruit, tree gum/exudates
 - Marmosets rely heavily on tree gum, chew holes in tree bark to access
- Social organization
 - Tamarins: typically multimale-multifemale
 - Marmosets: multimale-multifemale, one male-multifemale, one female-multimale

Callitrichids

- Reproduction
 - Generally monogamous
 - Dominant breeding pair
 - Reproductive suppression in subordinates
 - High reproductive capacity!
 - Polyovulatory
 - Non-identical twinning most common
 - Permanent chimerism common due to placental vascular anastomoses and continuous placental hemopoiesis allowing stem cell crossover
 - Freemartiniism does not occur (aromatizing enzyme can convert androgens to estrone)
 - Gestation
 - Marmoset: 148 days
 - Tamarin: 183 days
 - Post-partum estrus in marmosets
 - Will breed year-round in captivity
 - Family groups
 - Cooperative rearing

Callitrichids

- Housing
 - Pairs or family groups
 - Plenty of vertical height, climbing structures, and perches
 - Provide multiple feeding stations above the floor
 - Nest boxes – can be used as transfer/capture boxes
 - Scent marking
 - Easily cold-stressed
 - Diet
 - Susceptible to hypoglycemia
 - Require Vitamin D3 and C in diet

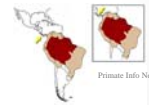
Callicam! <http://pin.primare.wisc.edu/callicam/calliframes.html>

Callitrichids

- Marmoset research models
 - Reproductive biology
 - Chimerism
 - Parkinson's disease
 - Multiple sclerosis
 - Experimental autoimmune encephalitis (EAE) resembles MS
 - Infectious disease
 - Viral hepatitis
 - HSV-1
 - Toxicology and drug development
- Tamarin research models
 - Chronic colitis
 - Colon cancer
 - Hepatitis A
 - GB Virus B as a model for Hepatitis C

Squirrel Monkeys

- Most commonly used NWM in US biomedical research
- Anatomy
 - Two main groups, five species
 - *Saimiri boliviensis*, *Saimiri sciureus*
 - Differentiate by shape of fur over eyes (Roman vs. Gothic arch), some color differentiation
 - Sexual dimorphism – males 650g-1.25kg, females 650-900g
 - "Fatted" males
 - Canines longer in males
 - Height: 11-12.5 inches
 - Lifespan: up to 20 years
 - High circulating levels of free cortisol
- Habitat
 - Central and South America
 - Arboreal
 - Eat insects, fruits, seeds, small animals
- Social Organization
 - Large multi-male/multi-female groups
 - Adult females typically unify group although social structure can vary by species



Squirrel Monkeys



Primate Info Net

Saimiri sciureus -- Gothic arch



<http://tickhivemind.net/tags/saimiri/interesting>

Saimiri boliviensis -- Roman arch

Squirrel Monkeys

- Reproduction
 - Breeding season typically December – March
 - Males undergo rapid weight gain prior ("fattening")
 - Females cycle during breeding season
 - Polygamous
 - Single offspring
 - Gestation: 145 days
 - Males do not participate in infant care
- Housing
 - House in pairs or groups if possible (male pairs may fight)
 - Prone to hypothermia
 - Scent-marking, urine-washing
 - Perch on tail – will develop tail ulcers if perch is not wide
 - Diet
 - Prone to hypoglycemia
 - Require Vitamin D3 and C in diet



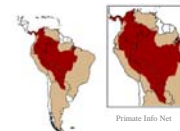
Infant rides on dorsum

Squirrel Monkeys

- Research Uses
 - Infectious disease
 - Malaria
 - Creutzfeldt-Jacob disease
 - Chagas disease
 - Addiction
 - Parkinson's disease
 - Alzheimer's disease
 - Periodontal disease
 - Steroid resistance
 - Reproduction
 - Assisted reproduction technology
 - Pelvic organ prolapse

Owl Monkeys

- Anatomy
 - Single genus with chromosomal/karyotypic variation
 - Eight species – *Aotus nancymaae* most common in research
 - Males and females similar in size
 - Height: 13-14 inches
 - Weight: 700g – 1.3kg
 - Lifespan: up to 20 years
 - Nocturnal
 - Large globe-like eyes
 - Lack tapetum lucidum
 - Poor color vision (more rods, less cones)
- Habitat
 - Central and northern South America
 - Arboreal
 - Mainly frugivorous (also eat insects, small animals, leaves)
- Social Organization
 - Male-female pairs or small family groups



Owl Monkeys

- **Reproduction**
 - Non-seasonal breeders in captivity
 - Monogamous
 - Males have low sperm counts
 - Typically singletons
 - Gestation 133 days
 - Males participate heavily in infant care
 - Infants carried by father
- **Housing**
 - Pairs or family groups preferable
 - Prefer warm temps
 - Provide diminished lighting during "dark" cycle, offset from normal day
 - Nest boxes
 - Scent-marking, urine-washing
 - Require Vit. D3 and C in diet



Owl Monkeys

- **Research Uses:**
 - Infectious disease
 - Dengue
 - Hepatitis A and E
 - HSV-1
 - Malaria
 - Vision

Baboons

- Largest OWM
- Single species (*Papio hamadryas*) with five regional subspecies – *Papio hamadryas hamadryas*, *anubis*, *papio*, *cy노cephalus*, *ursinus* (controversial)
- **Anatomy**
 - Marked sexual dimorphism
 - Males: 25kg, large canines
 - Females: 15kg
 - Immune system similar to humans (same IgG subclasses)
- **Habitat**
 - Sub-Saharan Africa
 - Terrestrial
 - Omnivorous (seeds, leaves, fruit, insects, small animals)
- **Social Organization**
 - Strict social hierarchy (matrilineal dominance hierarchy)
 - Typically multimale-multifemale troops



Baboons

- **Reproduction**
 - Prominent perineal sex skin
 - Can use to determine stage in menstrual cycle
 - Breed year-round
 - Detect pregnancy with rectal exam or U/S
 - Gestation ~180 days
 - Single births
 - Males may participate in infant care (majority of care by females)



What stage of estrus is shown in this image?

Answer: ovulation – maximum tumescence

Baboons

- Standard indoor metal cages, indoor/outdoor groups, or outdoor corrals
- Big, long-legged - require more height than macaque sp.
- Will use perches
- Cages must be stronger for these species



<http://bbiomed.org/primate-research-center/primates/baboons>

Baboons

- **Research Uses:**
 - Biomedical devices
 - Cardiovascular
 - Atherosclerosis
 - Osteoporosis
 - Infectious disease
 - Chagas disease
 - Schistosomiasis
 - Reproduction
 - Endometriosis
 - Contraception
 - Premature birth
 - Stroke (focal cerebral ischemia)
 - Transplantation
 - Pancreatic islet transplantation for diabetes

Restraint

- Physical
 - Hand-catch with protective gloves
 - Useful in NWMs and young OWMs (<5kg)
 - Nest boxes useful for capture in callitrichids
 - Squeeze cages
 - Tether and vest
 - Pole and collar
- Chemical
 - Ketamine, Telazol = most common
 - Fasting times reduced in NWM to prevent hypoglycemia
 - Hypothermia and hypoglycemia common complications in NWM

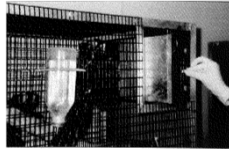


Figure 8. Offering a marmoset a vest to enter the nest/transport box.
Layne, Donna G.; Power, Rachel A. Husbandry, Handling, and Nutrition for Marmosets. 2003. Comp Med 53(4): 351-359(9)



Donnelly, M. Capturing and handling Marmosets. Laboratory Primate Newsletter 37(4):2000

Blood collection

What is the most common blood collection site in NHPs?

Answer: femoral vein

- NWMS
 - Femoral vein
 - Saphenous
 - Tail vein
- OWMS
 - Femoral vein
 - Saphenous vein
 - Cephalic vein

Guide requirements

- Social housing considered the norm
- Environmental enrichment
- Minimum space requirements

TABLE 3.5 Recommended Minimum Space for Nonhuman Primates Housed in Pairs or Groups*

| Animals | Weight,* kg | Floor area/animal,* sq ft | Height,* in. (cm) | Comments |
|------------------------------|-------------|---------------------------|-------------------|--|
| Monkeys† (including baboons) | | | | Cage height should be sufficient for the animals to comfortably stand erect with their feet on the floor. Baboons, gibbon monkeys, and other longer-legged species may require more height than other monkeys, as might long-tailed animals and animals with prehensile tails. Overall cage volume and floor perch space should be considerations for many neotropical and afrotropical species. For brachiating species cage height should be such that an animal can, when fully extended, swing from the cage ceiling without having its feet touch the floor. Cage design should enhance brachiating movement. |
| Group 1 | Up to 1.5 | 2.3 (0.20) | 30 (76.2) | |
| Group 2 | Up to 1.5 | 3.0 (0.28) | 30 (76.2) | |
| Group 3 | Up to 10 | 4.3 (0.4) | 30 (76.2) | |
| Group 4 | Up to 15 | 6.0 (0.56) | 32 (81.3) | |
| Group 5 | Up to 20 | 8.0 (0.74) | 34 (86.4) | |
| Group 6 | Up to 25 | 10 (0.93) | 44 (111.8) | |
| Group 7 | Up to 30 | 15 (1.40) | 44 (111.8) | |
| Group 8 | >30† | 25 (2.32) | 60 (152.4) | |
| Chimpanzees (†)†† | | | | For other ages and large brachiating species cage height should be such that an animal can, when fully extended, swing from the cage ceiling without having its feet touch the floor. Cage design should enhance brachiating movement. |
| Juveniles | Up to 10 | 15 (1.4) | 60 (152.4) | |
| Adults† | >10 | 25 (2.32) | 84 (213.4) | |



Guide for Care and Use of Laboratory Animals, 8th ed. NRC 2011

DISEASES

Note: This is NOT all-inclusive

Measles

- RNA paramyovirus, genus *Morbillivirus*
- Not a natural infection in NHPs (Anthropozoonosis)
- Aerosol transmission
- Severe disease in New world monkeys (marmosets, owl, squirrel)
 - GI system most affected in NWM, often no rash
 - Fatal gastroenterocolitis in marmosets
 - High mortality
- Causes immunosuppression
- May cause false-negative TB tests
- Modified-live vaccination
 - Interferes with serology, monovalent expensive
 - False-negative TB test
 - NHPs do not usually mount a response to canine distemper vaccine



Maculopapular rash

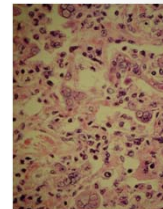
Measles



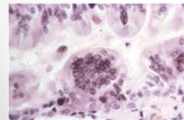
Marmoset GI – severe gastroenteritis



Koplik spots



Lung with syncytial cells

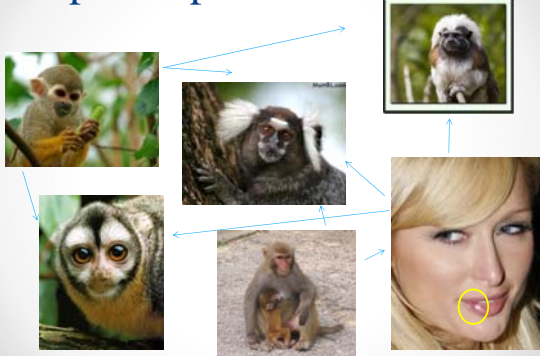


• Syncytial Cell with inclusions



Coryza

Alphaherpesvirinae



Alphaherpesviridae

- DNA virus
- Natural host
 - Subclinical or self-limiting infection
 - Oral, genital vesicles
 - Life-long infection with latency in sensory ganglia
 - Periodic reactivation and shedding
- Aberrant host
 - Systemic, often fatal disease

Alphaherpesvirus

- Which alphaherpesvirus causes mild or inapparent disease in this monkey?



- And severe, generalized disease in this monkey?



Answer: Herpes T

Saimirine herpesvirus 1

- AKA: Herpesvirus tamarinus, Herpes T
- Natural host – squirrel monkey
 - Asymptomatic or oral vesicles, ulcers
- Aberrant host – owl monkey, marmoset, tamarins
 - Generalized disease with depression, vesicular rash, oral vesicles, generalized ulcers and necrosis
 - Death in 24-48h
 - Eosinophilic intranuclear inclusion bodies

What is often an early sign of this disease in a marmoset or owl monkey?

Extreme pruritus

Other Alphaherpesviruses

- Herpes simplex virus (HSV-1, HSV-2)
 - Natural host: humans
 - Human → monkey and monkey → monkey transmission
 - Aberrant host: Apes, owl monkeys, marmosets, tamarins
 - Can cause lethal disseminated disease
 - Disease in owl monkey may be indistinguishable from Herpes T
- Cercopithecine herpesvirus 1 (Herpes B)
 - Natural host: macaques
 - Aberrant host: non-macaque species. Severe disease reported in owl monkeys and marmosets
 - Can cause fatal encephalitis in human!

What is the take-home message?

Do not mix species!

Herpesvirus Papio 2

- Papiine herpesvirus 2
- Alphaherpesvirus
- Host: endemic in baboons
- Outbreak of vesicular disease in baboon colony originally attributed to SA8
- Lesion similar to herpes simplex 2 in humans
 - Predominately genital vesicles and ulcers
 - Oral ulcers possible
 - Likely venereal transmission
 - Latent with periodic reactivation
 - Possible model for herpes simplex 2 in humans



Gammaherpesvirinae

- Oncogenic
- Usually asymptomatic in immunocompetent natural hosts
- Lymphocryptoviruses (many)
 - Similar to human Epstein-Barr virus
 - Associated with large cell lymphomas in New World Monkeys
- Rhadinoviruses (Herpesvirus ateles, saimirine herpesvirus 2)
 - Common asymptomatic infection in spider and squirrel monkeys
 - Associated with malignant lymphoma or leukemia in aberrant hosts (owl monkey, marmosets, tamarins)

Parainfluenza viruses

- Paramyxoviridae
- Types 1,2 (SV5, SV41), and 3 associated with disease in NWM
- Not very species specific
 - Transmission can from infected humans
- Aerosol or contact with secretions
- Mild to severe upper respiratory disease
- Multinucleated syncytial cells with INIBs and ICIBs

Gammaherpesvirus



Ateles geoffroyi (Spider monkey)

- What herpesvirus causes no disease in this monkey but causes lymphomas in owl monkeys and marmosets?

Answer: Herpesvirus Ateles
 • Rhadinovirus
 • Spider monkey is the natural host

What human gammaherpesvirus can cause lymphomas in owl monkeys and marmosets?

- Answer: Epstein-Barr virus
- Lymphocryptovirus

Monkeypox

- Orthopoxvirus
- NWM, OWM, and apes susceptible
- Zoonotic
- Vesicular exanthema, visceral lesions can occur
- Intracytoplasmic eosinophilic inclusion bodies
- Immunologically related to smallpox and vaccinia
 - Vaccinia protective



What animal was associated with a US monkeypox outbreak in 2003?

Answer: prairie dogs

Callitrichid hepatitis virus

This monkey developed lethargy and jaundice after being fed newborn mice. What is the likely etiology?

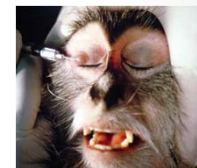


Answer: Lymphocytic choriomeningitis virus (Callitrichid hepatitis virus)

- Rapidly progressive viral hepatitis in marmosets and tamarins
- Rodent reservoir – can spread by feeding non-SPF pinkies

Tuberculosis

- Mycobacterium tuberculosis complex
 - *M. tuberculosis, M. bovis, M. africanum, M. microti, M. canetti
 - M. avium = atypical TB
- Tuberculin skin test (TST)
 - 0.1ml (0.05ml in marmosets)
 - intradermal Old Mammalian Tuberculin in eyelid *gold standard
 - Observed at 24,48,72h for swelling and erythema, grade 1-5



What technique is shown in the image at left? Why is it used?

Abdominal skin TB test. Often used for retesting of a suspected positive

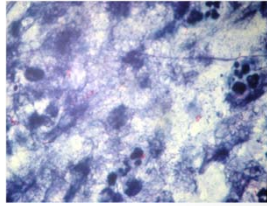
Tuberculosis

- NWMs \leq susceptible than OWM



Positive TB test (grade 4) in a marmoset

Wachtman LM, Miller AD, Xia D, Curran EH, Mansfield KG. Colonization with Nontuberculous Mycobacteria is Associated with Positive Tuberculin Skin Test Reactions in the Common Marmoset (*Callithrix jacchus*). 2011. *Comp Med* 61(3):278-284



Acid-fast bacteria on tracheal wash

Name an acid-fast stain: Ziehl-Neelson

Klebsiella



What is this condition in a baboon?

Air sacculitis

What bacteria has been associated with this condition in owl monkeys?

Klebsiella pneumoniae

- Gram-negative bacteria
- Associated with significant morbidity and mortality in NHPs
 - NWMs susceptible to acute death
- Peritonitis, septicemia, pneumonia, enteritis, air sacculitis
- May be associated with shipping, overcrowding, trauma, maternal neglect

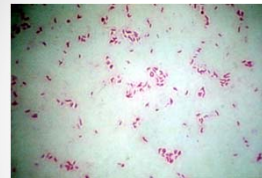


Rhesus air sacs

Pasteurella multocida

- Opportunistic pathogen of owl and squirrel monkeys
- Reported in baboons secondary to surgical procedures, chronic catheters, and chair restraint
- Generally seen in association with shipping or animals in poor condition
- Owl monkeys
 - Pneumonia, meningitis
- Squirrel monkeys
 - Nystagmus, head tilt, circling
 - Meningitis, myocarditis, otitis media
- Baboons
 - Air sac infection, abscesses

Campylobacter



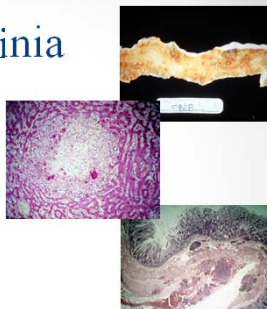
This spiral or gull-shaped bacteria was cultured from the feces of a tamarin with diarrhea. Identify the bacteria

Campylobacter spp. (*jejuni* and *coli* most common)

- Watery or mucohemorrhagic diarrhea
- Asymptomatic carriers common
- Erythromycin the treatment of choice

Yersinia

- Yersinia enterocolitica* and *pseudotuberculosis* seen in outdoor housed marmosets, owl monkeys, squirrel monkeys, OWMs
- Triad of lesions
 - Hepatic and splenic necrosis/abscess
 - Mesenteric lymphadenopathy
 - Ulcerative enterocolitis
- Squirrel monkeys: cervical lymph nodes enlarged with *Yersinia pseudotuberculosis*

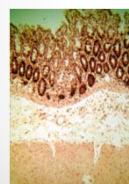


What technique is used to enhanced Yersinia growth on culture?

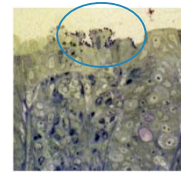
Answer: cold enrichment

Enteropathogenic E. coli (EPEC)

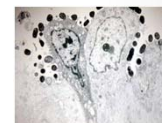
- Common cause of diarrhea in marmosets, tamarins, and SIV-infected macaques
- Acute hemorrhagic diarrhea
- Asymptomatic carriers common



Colitis (H&E)



Attaching and effacing E. coli at the brush border, toluidine blue stain



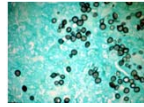
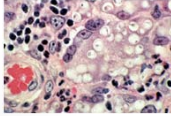
EPEC on EM

Histoplasmosis

These lesions were observed on a baboon.



On histopathology of the lesions, these organisms were seen with a GMS stain. What is the disease?



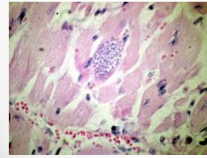
Histoplasma capsulatum var. *duboisii* – reported in baboons.

Trypanosoma cruzi

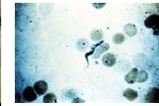


Enlarged, mottled heart

- Chagas disease
- Natural infection in NWMs
- Trypomastigote in blood
- Amastigote in tissue pseudocysts (skeletal and cardiac muscle)
- Myocarditis = most commonly mentioned lesion in NHPs



Leishmanial forms (amastigotes) in cardiac muscle

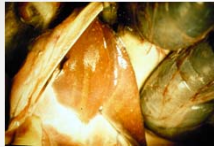


Elongated leaf-like body and a flagellum

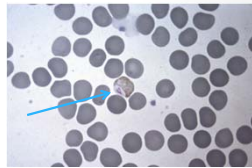


Reduviid (kissing) bug!

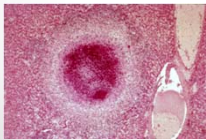
Hepatocystis kochi



Scattered gray-white foci on baboon liver = mature merocysts



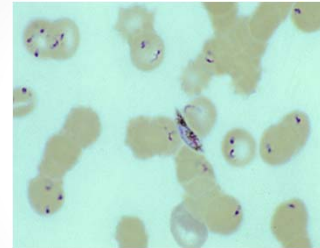
Trophozoites in blood smear



Ruptured cyst in liver causes eosinophilic granuloma

- Protozoa, infects OWM (including baboons), apes
- Schizogony occurs in the liver, not in the blood (unlike malaria)
- Transmitted via midge (Culicoides)
- Usually no clinical signs

Malaria



These organisms were identified on a blood smear from a NHP that had anorexia, fever, and anemia. What is the diagnosis and what is the organism?

Answer: Malaria, *Plasmodium* sp.

Malaria



Anopheles mosquito vector

- NWMs
 - *Plasmodium simium*, *P. brazilianum*
 - OWMs
 - *P. cynomolgi*, *P. inui*, *P. knowlesi*, *P. gonderi*
 - Man
 - **P. vivax*, **P. falciparum*, *P. malariae*, *P. ovale*
 - * Squirrel and owl monkeys susceptible
 - Lifecycle
 - Hepatic and erythrocytic phases
 - Time to complete erythrocytic cycle characteristic for each species
 - 24, 48, or 72 h
 - Clinical signs due to release of organisms from RBCs (schizogony)
 - Typically mild disease in natural hosts
 - *P. brazilianum* more pathogenic in natural hosts
- Which plasmodium has a quotidian (24h) cycle?
P. knowlesi, causes severe disease in rhesus

Pentastomids



Identify this organism

Answer: pentastomid nymph

- NHPs are intermediate hosts for the nymph form
- *Porocephalus*: tend to be found in OWM
- *Armillifer*: tend to be found in NWM
- Adult forms found in snake



Adult worms in snake

Trichospirura leptostoma

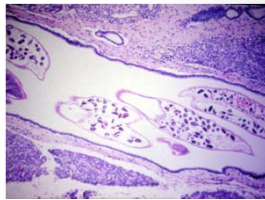
- Nematode found in marmosets, tamarins, squirrel monkeys, owl monkeys

In what organ is this nematode usually found?

Answer: inhabits pancreatic ducts

- may cause chronic pancreatitis
- Associated with marmoset wasting syndrome?

What is the intermediate host? Cockroach



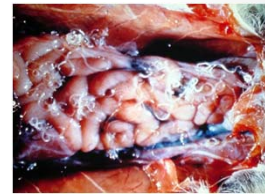
Trichospirura leptostoma in pancreatic duct of a NWM

Dipetalonema

Identify this parasite which was found in the abdomen of a NWM

Answer: *Dipetalonema* sp.

Live in serous cavities, may cause fibrinopurulent peritonitis or pleuritis



Smaller worm = male

Acanthocephalans



Intestine from a marmoset



Opened

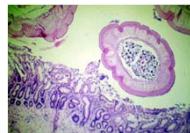
What is the diagnosis? *Prosthenorchis* sp. (AKA thorny-headed worm)

* *Prosthenorchis elegans*: cecum and colon
P. spirula: terminal ileum

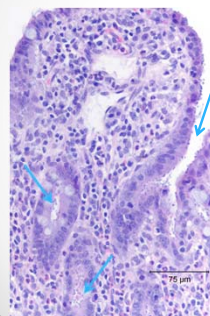
Can this parasite cause clinical signs?

Yes – mechanical blockage, penetrate mucosal surface which can cause perforation and peritonitis

- Cockroach intermediate host
- Fecal float ineffective for detection, use direct smear or sedimentation



Cryptosporidiosis



- These organisms were identified in the intestine of a neonate.
- Identify the organism

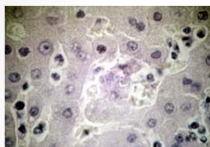
Cryptosporidium parvum

- Protozoa
- Typically self-limiting in immunocompetent animals
- Diarrhea, dehydration in neonates and immunocompromised

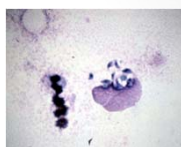
- What is the main form of treatment?

Supportive care

Toxoplasmosis



PAS liver



Giemsa brain

- An outdoor housed NWM presented with weakness, neurologic signs and died several days later

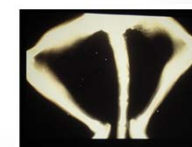
What is the organism?

Toxoplasma gondii

- NWM more susceptible than OWM
- Infected via oocysts shed in feline feces, or eating cysts in meat
- Tachyzoites are banana-shaped, cysts in tissues

Vitamin D deficiency

- NHPs that receive inadequate sunlight or UVB radiation need Vitamin D supplementation
- Vitamin D3 is the preferred form for diets (New World monkeys utilize D2 poorly)
 - D2 – plant form
 - D3 – animal form
- Deficiency
 - Simian bone disease (rickets) – secondary hyperparathyroidism
 - leads to bone resorption and fibrous replacement



Vitamin C deficiency (Scurvy)

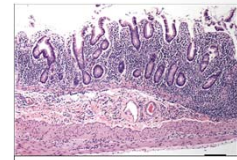
- NHPs must have diets supplemented with Vitamin C
 - What enzyme necessary for Vit. C synthesis do NHPs lack?
 - L-gulonolactone oxidase
- Non-stabilized Vit. C has a shelf life of 3 months
- Associated with cephalohematoma, hyperostosis of the skull in squirrel monkeys
- Other NHPs: gingival bleeding, lameness, bruising, epiphyseal fractures, subperiosteal hemorrhage



Marmoset Wasting Syndrome

A marmoset presented with weight loss, hair loss, muscle atrophy, and colitis. What is the likely diagnosis?

- Is it a disease? Or is it nutrition?
 - Vitamin deficiencies have been implicated (Vit. E, protein)
 - Food allergens
 - Underlying intestinal infections
- Clinical signs
 - weight loss, skeletal muscle atrophy, hair loss, ventral edema, anemia, chronic colitis
- Chronic segmental lymphocytic enterocolitis (CLE)



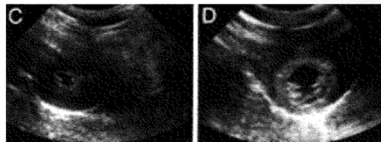
Lymphoplasmocytic enterocolitis

Cardiomyopathy

What degenerative disease is common in aged owl monkeys and is a major cause of death?

Answer: cardiomyopathy

Also common in some squirrel monkey colonies



Echocardiograph from a normal owl monkey (c) and one with dilated cardiomyopathy (d)

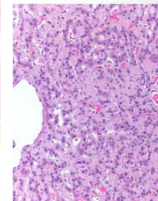
Rishniw, M., Schiavetta, A., Johnson, T., Erb, H. Cardiomyopathy in Captive Owl Monkeys (*Aotus nancymae*) *Comp Med.* 2005; 55(2):162-168

Amyloidosis

- Extracellular deposition of amyloid in various body tissues (liver, kidneys, GI, pancreas)
- Secondary or reactive (AA) - associated with chronic inflammatory stimulation
- Typically presents as weight loss and lethargy
 - Hepatomegaly on PE
- May be extensive before clinical signs develop



Hepatomegaly with waxy discoloration



Sinusoidal amyloid deposits

What stain is used to identify amyloid? Answer: Congo red

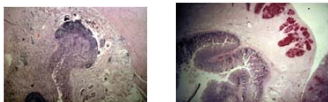
What technique can be used along with Congo red to help with identification? Answer: polarized light

Chronic colitis

This animal presented with diarrhea and weight loss. A tumor was found in the colon at necropsy.



What is the likely tumor, and what pre-existing condition is it associated with?



Answer: Colonic adenocarcinoma in a cotton-top tamarin, associated with chronic colitis

- Chronic colitis is very common in captive cotton-top tamarins
- Tumors often metastasize

Tooth Root Abscess

- Very common in NWMs, especially squirrel monkeys
- Associated with severe wear and tooth fracture
- Usually presents as swelling under the eye
- Staphylococcus aureus and anaerobes often isolated
- Treatment: pull tooth +/- antibiotics



Laboratory Animal Medicine 2nd edition

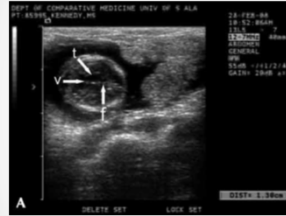
Hypoglycemia



Glucometer reading from a squirrel monkey. Diagnosis?

- NWMs may develop hypoglycemia as a primary disorder
- Weakness, disorientation, lethargy, seizures
- Check glucose in animals that are taking a long time recovering from anesthesia
 - Squirrel monkey < 40 mg/dL
 - Owl monkey < 50 mg/dL
- Treat with oral glucose or IV 5% dextrose

From recent literature....



At the left is an ultrasound image used to measure the biparietal diameter of an owl monkey fetus. What is this measurement used to indicate in NHPs?

Gestational age

Michele Schuler, A; G Brady, Alan; W Tustin, George; L Parks, Virginia; G Morris, Chris; R Abee, Christian. **Measurement of Fetal Biparietal Diameter in Owl Monkeys (*Aotus nancymae*)**. 2010. JAALAS 49(5): pp. 560-563

From recent literature....



Dyscoria was noted in a female and her two offspring. A third offspring and two of the cagemates were found dead. Oral ulcers with eosinophilic intranuclear inclusion bodies were found on necropsy. What is the diagnosis?

- Cytomegalovirus
- Herpesvirus simplex*
- Callitrichid hepatitis virus
- Paramyxovirus

Answer: b – *Herpesvirus simplex*

Gozalo, Alfonso S.; Montoya, Enrique J.; Weller, Richard E. **Dyscoria Associated with Herpesvirus Infection in Owl Monkeys (*Aotus nancymae*)**. 2008. JAALAS 47(4): 68-71

From recent literature....

- Which NHP parasite can be diagnosed with a fecal antigen-capture assay ?

- *Giardia intestinalis*
- *Trichuris trichiura*
- *Pneumonyssus simicola*
- *Strongyloides cebus*

Answer: Giardia

A Kramer, Joshua; M Hachey, Audra; M Wachtman, Lynn; G Mansfield, Keith. **Treatment of Giardiasis in Common Marmosets (*Callithrix jacchus*) with Tinidazole**. Comp Med, 59(2) 2009. pp. 174-179(6)

From recent literature....

- Squirrel monkeys have higher circulating levels of which hormone(s) compared to humans?
 - Cortisol
 - Testosterone
 - Insulin
 - Growth hormone
 - Thyroxine

Answer: Cortisol and testosterone

L Gross, Katherine; M Westberry, Jenne; R Hubler, Tina; W Sadosky, Patti; J Singh, Ravinder; L Taylor, Robert; G Scammell, Jonathan. **Androgen Resistance in Squirrel Monkeys (*Saimiri spp.*)**. 2008 Comp Med, 58(4): pp. 381-388.

Scammell, Jonathan G.; Westberry, Jenne M.; Sadosky, Patti W.; Hubler, Tina R.; Williams, Lawrence E.; Gibson, Susan V.; Singh, Ravinder J.; Taylor, Robert L.; Shackleton, Cedric H.L. **Cortisol Metabolism in the Bolivian Squirrel Monkey (*Saimiri boliviensis boliviensis*)**. 2006. Comp Med. 56(2): 128-135

From recent literature....



Identify this equipment, often used as a refinement in NHP studies

Answer: Vascular access ports – allow repeated venous sampling, improve safety, and reduce need for chemical restraint

L Graham, Melanie; A Mutch, Lucas; F Rieke, Eric; Dunning, Michele; K Zalondek, Elizabeth; W Faig, Aaron; J Hering, Bernhard; Schuurman, Henk-Jan. **Refinement of Vascular Access Port Placement in Nonhuman Primates: Complication Rates and Outcomes**. 2010. Comp Med, 60(6):479-485

I would like to acknowledge Diane Forsythe and Mary Grant from NIEHS and Susan Spray from Scripts for many of the images used in this presentation