DISEASES OF THE OPOSSUM
(DIDELPHIS MARSUPIALIS): A REVIEW1,2

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SUMMARY • The opossum (Didelphis marsupialis) is being utilized as a research animal with increasing frequency. The naturally occurring and experimentally induced diseases that affect this species have been reviewed. They include rabies, pseudorabies, B virus infection, tuberculosis, tularemia, leptospirosis, relapsing fever, streptococcal infections, and endemic murine typhus. The opossum is the host for numerous parasites. Helminths are most commonly encountered, and a number of ectoparasites are associated with the opossum. D. marsupialis serves as a reservoir for Chagas' disease and is also susceptible to other protozoan infections. Histoplasmosis occurs in opossums, and dermatophytes have been isolated from this species. Diseases such as rickets, nephritis, pneumonia, hepatitis, and various neoplasms also afflict the opossum. All of the reported diseases should be considered important, particularly in opossums that are obtained directly from the wild for use in research.

The common opossum (Didelphis marsupialis) is finding increasing use as a research animal. Its position in the phylogenetic scale makes it particularly suitable for investigations in such fields as immunology and neurology, and in the behavioral sciences. Some of the scientific information that has been derived from the opossum was reviewed recently (91, 92). General management methods and husbandry practices for the opossum have been published by a number of authors (14, 28, 40, 106, 124), and some of the infectious diseases of this species have been reviewed (7). Experimental techniques and some of the health measures applicable to opossums maintained for research purposes have also been outlined (91). Aside from reports such as these, little information appeared to be readily accessible regarding the specific diseases that have been encountered in the opossum. This review was undertaken to ascertain the extent to which diseases have been observed or studied in that species of opossum (D. marsupialis) which is native to the continental United States and Canada.

INFEKTIOUS DISEASES

VIRAL DISEASES

Rabies: The incidence of naturally occurring rabies infection in opossums appears to be low. Thirteen confirmed cases were reported in the United States over the 4-year period from 1964 through 1967 (133-136). The usual clinical manifestations of the experimental disease in this species are anorexia and paralysis (8). However, the opossum is highly resistant to experimental rabies (8, 29, 30, 125). Young opossums appear to be more susceptible than adults (6).

Pseudorabies: The opossum is susceptible to pseudorabies virus infection (131). Anorexia, excessive salivation, clonic spasms, and convulsions were seen following intramuscular injection of virus into 2 opossums. One opossum received the Aujeszky strain and the other was given Strain A of pseudorabies virus. Death occurred on the 6th day after...
inoculation with the Aujeszky strain, and the other opossum was killed when it became moribund on the 10th post-inoculation day. The gross lesions, limited primarily to the injection site, included lacerations of the skin and hemorrhage and edema in the adjacent muscles.

*Equine encephalomyelitis*: The results of intracerebral inoculation of 2 opossums indicated that this species was refractory to eastern and western equine encephalomyelitis virus infection (130). The opossums survived massive doses of the viruses.

*B-virus*: Experimental infection of 1 opossum with B-virus resulted in progressive paralysis and death in 9 days (130).

**Bacterial Diseases**

*Mycobacterial infections*: The opossum is considered resistant to tuberculosis (56). Four cases, including 2 in pet opossums, have been reported (54-56, 58, 67). Lesions were confined to the abdominal cavity and involved the mesenteric lymph nodes and the spleen. The lesions were pale yellow and were composed of irregular, marginated masses of conglomerate tubercles containing acid-fast bacilli. Isolation and identification of the causative agent was not reported in any of these cases.

Fatal infection with an atypical mycobacterium of Runyon Group III was observed in 1 captive opossum (107). Lesions involved the intestine, liver, spleen, and mesenteric lymph nodes.

*Pasteurella infections*: Several cases of tularemia have occurred in humans who killed, skinned, and dressed opossums or had been bitten by infected opossums (60, 61, 102). The lesions of experimentally induced tularemia in opossums include areas of necrosis in the spleen, liver, and lymph nodes (139). Significant antibody titer to *Pasteurella tularensis* was found in 11.9% of 544 opossums examined in 1 survey; the organism was isolated from the spleen of 1 opossum (101). In another survey, serums from 7 of 24 opossums were positive (20).

*Leptospiral infections*: Based on bacterial isolation and serologic studies, the opossum appears to be an important host for leptospirosis. In a survey of 955 opossums, 15.6% were positive for leptospirosis (65). *Leptospira ballum* infection appeared to be the most common (38, 63, 65, 121, 128, 141). Infection with *hyos* strains was found frequently (64, 65, 121, 122). Other leptospires that have been found in the opossum are *L. hebdomadis* (62, 65, 121), *L. autumnalis* (38, 65, 121), *L. australis A* (65), *L. canicola* (100), *L. pomona* (63, 120), *L. butembo* (38), *L. grippotyphosa* (38), and *L. icterohaemorrhagiae* (38). Clinical signs of leptospirosis have not been reported.

*Borrelia infections*: The opossum has been reported as a natural reservoir for relapsing fever spirochetes (*Borrelia recurrentis*) (11).

*Streptococcal infections*: *Streptococcus* spp have frequently been isolated from captive opossums with endocarditis. *Strep. pyogenes* was isolated from 3 of 10 opossums with acute endocarditis (41), *Strep. viridans* from 1 of 3 (92), and α- and β-hemolytic streptococci from 10 of 15 opossums (124). Other bacteria (*Escherichia coli*, *Proteus mirabilis*, *Proteus* spp, *Salmonella boro*, *Sal. spp*, *Aerobacter* spp, and *Pseudomonas* spp have also been isolated from heart valve lesions of opossums, but with much less frequency (124). Other lesions observed in opossums with bacterial endocarditis were myocarditis, amyloidosis of the spleen, liver and kidneys, microabscesses of the brain, focal necrosis of lymph nodes and adrenal glands, acute infarction of the kidneys, and pyelonephritis (124).

*Salmonella infections*: *Sal. typhi* was isolated from the kidney and *Sal. gie* from the urine of another 3 wild opossums (126). Fatal salmonella infection was reported in 2 captive opossums (8). *Sal. boro* was isolated from 1 and *Sal. spp* and β-hemolytic *Strep.* from another of 21 captive opossums with vegetative valvulitis (119).

*Bordetella infections*: In a recent survey, the incidence of *Bordetella bronchiseptica*...
isolation from the tracheas of 105 opossums was reported as less than 2% (129).

Rickettsial Diseases

Rickettsia prowazekii infections: The opossum is susceptible to experimental typhus infection (12) and may be a reservoir for endemic murine typhus (26). Although the serums of 2 of 27 opossums examined in 1 survey were reactive, the findings were considered doubtful because their titer were low and other test animals could not be infected with suspensions of their brains (88). In another serologic survey, 3 of 345 opossums tested were positive (110). Although infected fleas (Ctenocephalides felis) have been obtained from opossums, the recoveries were made in an area of endemic murine typhus, and it is possible that the fleas may have been infected from a murine source (82). Isolation of typhus rickettsiae from naturally infected opossums has not been reported (82, 88).

Mycotic Diseases

In a survey of 379 opossums, Trichophyton mentagrophytes was isolated from 6 and "red" Microsporum from 11 opossums (86). Trichophyton mentagrophytes has also been isolated from opossums in other surveys (103, 104). The absence of visible skin lesions on the opossums from which the isolations were made may indicate that the fungi were saprophytes.

Four cases of histoplasmosis have been reported (36, 37). Histoplasma capsulatum was isolated from the liver.

Parasitic Diseases

Protozoan Infections

Trichomonas didelphis and Tetra tri cho monas didelphis have been isolated from the intestines of opossums (1, 73, 108). These organisms are probably the same (1).

Trypanosoma cruzi, the agent of Chagas' Disease, was first isolated from 8 opossums in 1942 (113). Subacute myocarditis was observed in 7 of them at necropsy. Survey results indicate that up to 17% of opossums examined harbor T. cruzi or T. cruzi-like hemoflagellates (13, 99, 111, 112). The organisms were found in the blood, heart muscle, kidney, peritoneal fluid, and urine. Infected opossums generally have been identified in areas coincidental with the range of triatomid bugs that are vectors for T. cruzi. A trypanosome resembling T. cruzi has also been isolated from the blood and skin of an opossum (74).

Coccidiosis was described in 1 opossum (138). Isospora belli was found in the epithelium and subepithelium of the upper small intestine, the lumen of which was filled with blood.

Besnoitia jellisoni was obtained from the cranial dural sinuses of an opossum; the gross lesions were yellow-grey masses (127). Infection with sarcosporidia was reported in 5 of 90 opossums observed at necropsy (124).

Helminth Infestations

Internal parasitic infection is common. Table 1 lists the helminth parasites reported and their location in the opossum. Nematodes appear to be most frequently encountered, followed by the cestodes, trematodes, and Acanthocephala (21). The majority of the reports contain descriptions of the parasites, but little information is available regarding their effects upon the opossum or methods for their control.

The common stomach worm (Physaloptera turgida) of the opossum is usually found in the stomach and intestines, and occasionally in the liver (23). The worms are firmly attached to the mucosa and cause hyperemia, erosion, and ulcers (22, 23, 42, 90, 124). The clinical signs associated with P. turgida infection include profuse diarrhea, loss of weight, deterioration of the hair coat, anorexia, and death. Oral administration of car-
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<tr>
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<td>Cruzia americana</td>
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<td>Trichurus munteri</td>
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<td>Trichurus sp.</td>
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<td>Viannia burdocki</td>
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<td>Physaloptera sp.</td>
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<td>&quot;ascarillais&quot;</td>
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**Cestodes**

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<tr>
<td>Anaplocephala sp.</td>
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<td>Moscestoides sp.</td>
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<td>Mesostoides variabilis</td>
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<td>Mecestoides sp.</td>
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<td>Hymenolepis (Weinlandia) sp.</td>
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<td>Oochoristica sp.</td>
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<tr>
<td>Diphyllobothriidae</td>
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<td>Spiroptera mansonioides</td>
<td>(pierceroids)</td>
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<tr>
<td>&quot;cestodes&quot;</td>
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**Acanthocephala**

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<td>Echinorhynchus</td>
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<td>Microcephalus</td>
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<tr>
<td>Hamariniella microcephala</td>
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<td>Hamariniella tortuosa</td>
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<td>Hamariniella humida</td>
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<td>Macracanthorhynchus</td>
<td>ileum</td>
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* Not specified.

Bon disulfide results in complete removal of the worms and improvement in the condition of the opossums (90). The intermediate hosts of Physaloptera spp are said to include beetles, cockroaches, earwigs, and crickets (23, 72). It has been suggested, however, that infection results from direct exposure to a contaminated environment rather than through an intermediate host (90). The opossum is commonly infected with Cruzia tentaculata and this parasite is probably always associated with P. turgida (22).

The habitat of the adult Gnathostoma didelphi is the stomach (24). The immature form is found in the liver which, as a result, may be dark and cirrhotic. Worms may extrude from the surface of the liver and cause characteristic "gnathostome-scars" (5, 24). Gnathostoma spp may be found embedded within gastric ulcers and cause gastric perforation. Occasionally the worms burrow in the mucosa, and their heads and tails may extend from the tunnel which they form (5).
Although Gnathostoma spinigerum infestation has been reported in opossums in North America (22), the parasite may have been misidentified (3). Gongylonema longipiculum was observed in the wall of the esophagus (5).

The fluke, Paragonimus westermani, occurs in pairs, encysted in the lung of the opossum. Most of these cysts are visible on the surface of the lung; others are palpable within the lung (15).

The habitat of Harmostomum opisthotrias was described as the distal end of the ileum in the opossum (33). The parasites embed in the mucous lining of the intestine and cause inflammation. Strongyloides infestations are probably common but may not be detected unless the parasites are specifically sought for (95).

ECTOPARASITES

A variety of ectoparasites has been reported to affect the opossum (Table 2). Flea infestation is considered to be common, and a control program has been outlined (91). Sarcoptic mange associated with pruritis, loss of hair, and skin lesions has been reported (9).

DISEASES OF SPECIFIC ORGAN SYSTEMS

A number of lesions involving specific organs or systems have been reported in the opossum. Since most of the descriptions of these diseases resulted from observations made at necropsy, clinical descriptions are not available. In most cases, the cause of death was not reported. Table 3 lists the numbers of cases reported for each disease entity. Where sufficient information was available, the total number of animals studied is included.

Discussion

The opossum is susceptible to a variety of diseases. Parasitism by helminths is the most commonly reported. The most complete reports are based on findings from research animal colonies, individual zoological specimens, and wildlife surveys. Most reports deal with necropsy findings but are incomplete insofar as they fail to associate clinical observations, isolation of infectious agents, and histologic interpretations with the gross necropsy findings.

The majority of opossums used in research are procured from dealers who apparently obtain them directly from their native habitats. In 1966, 1967, and 1968 the numbers of opossums sold for research purposes were 1,088, 1,368, and 1,361, respectively, while approximately 324, 315, and 838 opossums were bred in research facilities (79–81). Opossums obtained from the wild are a hazard to public health. They should be carefully observed and handled during the quarantine and conditioning periods. Reported zoonotic diseases include leptospirosis, rabies, salmonellosis, tularemia, endemic typhus, and

<table>
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<td>Pulex similans</td>
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TABLE 2

ECTOPARASITES OF THE OPOSSUM

A variety of ectoparasites has been reported to affect the opossum (Table 2). Flea infestation is considered to be common, and a control program has been outlined (91). Sarcoptic mange associated with pruritis, loss of hair, and skin lesions has been reported (9).
trypanosomiasis (Chagas' disease).

In spite of the wide variety of infectious diseases which afflict opossums, the genus Didelphis has lived successfully and extended its range on this continent since the Pleistocene (27). However, their ability to survive appears to be severely compromised when they are kept in captivity. The high mortality observed among opossums following confinement may be attributable to stress (115, 123). Contributing factors may be parasitic infestations, changes in diet or inadequate diets, and exposure to pathogens in concentrations that are not regularly encountered in nature (123, 124).

In view of the present state of knowledge concerning the opossum, it seems that all of the reported diseases should be considered important. This is particularly pertinent when opossums that are obtained directly from the wild are confined for research purposes. Persons who handle opossums should regard them as potential sources of a variety of infectious agents. This is important not only to personnel who care for and condi-
tion opossums for the laboratory, but to the researcher who must evaluate the influence of intercurrent disease upon his experiment.

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June, 1970

DISEASES OF THE OPOSSUM

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