Review Article

Pinniped Zoonoses: A Review

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Abstract

Pinnipeds are monophyletic finned carnivorous marine mammals consisting of walruses, sea lions, fur seals. It is a very fascinating megafauna and has unidentified interaction with humans. The attraction to pinnipeds bloom during the summer vocational season where it goes unnoticed. They can live in proximity to humans. Pinnipeds cause variety of zoonotic disease being bacterial, viral, fungal and protozoal in origin and the major described diseases are 'seal finger', dermatitis and conjunctivitis. The majority of the affected group by pinniped zoonoses are tourists frequenting beaches, fisherman and hunters of pinnipeds, coastal habitants, individuals eating pinniped meat, biologists studying pinnipeds, veterinarians treating and conducting necropsies of pinnipeds, marine mammal rescuers, wildlife rehabilitators, animal trainers and marine mammal workers as a whole. This review as a whole is a concise information of zoonotic disease by pinnipeds.

Key words: *Erysipelothrix rhusipathiae*, Pinnipeds, Seal-Finger, Zoonotic Disease

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Introduction

Pinnipeds are monophyletic finned carnivorous marine mammals. They include walruses, sea lions, fur seals and true seals. Their ubiquitous presence from North to South and their polygamous ashore breeding habits make them more associated with humans and other terrestrial animals. Well documented facts regarding harbouring divergent zoonotic pathogen suggest that pinnipeds are capable of harboring zoonotic diseases. This is a review of familiar zoonotic disease which could be mediated and disseminated by pinnipeds. Pinnipeds are primarily pelagic, and they have extended migratory habits (Pinniped Classification and Paleontology, 2019) confirming their omnipresence all around the world's oceans and coastal areas, which are a lot times the major tourist spots. Sometimes they congregate in millions on the

shoreline and the adjacent terrestrial places, especially during the breeding season (Pinniped Classification and Paleontology, 2019). Gregarious habits of seals, their foreseeable yearly appearance trends, and their convivial behaviour with humans generate significant tourism (Kuleshov *et al*., 2008). Pinniped-tourism prevails at its pinnacle throughout summer, a time when their pupping activity co-exists with public vacations (Kuleshov *et al*., 2008). The swiftly growing pinniped-tourism industry has bloomed in an unsupervised manner (Kuleshov *et al*., 2008) over the past few years and has significantly explained the likelihood of human interaction with these animals.

The necessity of appropriate land surfaces to take rest, to molt, to breed, to give birth to pups, and feed their young brings pinnipeds to seaboard (Lance *et al*., 2003) and closer to human beings. Hauling-out in groups also allows for easier detection of terrestrial predators, curtailing predation risks (Hamilton *et al*., 2014). Pinnipeds have significant preference for warm and dry weather for hauling-out (Hamilton *et al*., 2014), which often at times is relatively close to human dwellings.

In countries like Norway, industrial fishing of harp seals is performed, and harbour grey seals are hunted as sport (Tryland *et al*., 2014). Outdoor butchering, onsite dressing and sealing of meat and the use of seawater for cleansing (Tryland *et al*., 2014) are a few considerable issues of microbiological risk related to seal meat stocking. Pathogens like *Trichinella spp*., *Toxoplasma gondii, Salmonella spp*. and *Leptospira spp.* are of vital zoonotic importance associated with seal meat (Tryland *et al*., 2014). Marine mammals, especially pinnipeds, serve as excellent indicators of emerging and re-emerging zoonotic pathogens and potential public health issues due to their coastal domain sharing habits and their similar food preferences to humans (Bossart, 2011). The longetivity, long-term coastal habitation, and the presence of pinnipeds at lofty trophic levels in food chain makes the coupled subject of zoonoses more intricate (Bossart, 2011). Being a fascinating megafauna, pinnipeds attract more human behavioural reaction and interaction (Bossart 2011).

Pinnipeds can carry numerous zoonotic diseases of viral, bacterial, fungal and protozoal origin (Hunt *et al*., 2008). Commonly described diseases include 'seal-finger' *(Mycoplasma spp*.), bacterial dermatitis and conjunctivitis (Hunt *et al*., 2008). Other possible zoonotic diseases contributed by pinnipeds include brucellosis, leptospirosis, tuberculosis etc. There are reports of food borne illness epidemics in Arctic and Australian native people who consume marine mammal meat in their conventional diet (Cawthorn, 1997; Tryland, 2002). Zoonotic pathogens are *Vibrio parahemolyticus* and *Staphylococcus aureus* are also seen in humans working with pinnipeds in captive setting (Palmer *et al*., 1998; Cowan *et al*., 2001). A recent epidemic in harbor seals (*Phoca vitulina*) due to avian influenza virus of subtype H10N7 (Seal/H10N7) caused high mortality in seals along the Northwest coast of Europe and coupled with the capability of infecting ferrets with the virus in experimental settings, demonstrates the serious zoonotic risk that pinnipeds can pose to humans (Van den Brand *et al*., 2016).

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Pinniped zoonotic diseases review below is a compilation of zoonotic agents transmitted by pinnipeds. The zoonotic risk mainly affects tourists frequenting beaches, fisherman and hunters of pinnipeds, coastal habitants, individuals eating pinniped meat, biologists studying pinnipeds, veterinarians treating and conducting necropsies of pinnipeds, marine mammal rescuers, wildlife rehabilitators, animal trainers and marine mammal workers as a whole. It causes a range of different disease as mentioned in Table 1.

Table 1: List of pinniped zoonotic diseases

Genus Species	Disease in Humans and Pinnipeds	Clincal Signs in Humans and Pinnipeds	Clinical Signs in Humans
Bacteria			
Mycoplasma phycocerebrale	Seal finger/ Mycoplasmosis	Arthritis and pneumonia	Dermatitis
Mycobacterium pinnipediii	Mycobacteriosis	Anorexia, lethargy, granulomatous dermatitis, granulomatous lesions in lungs and other organs	Anorexia, lethargy, granulomatous dermatitis, granulomatous lesions in lungs (Tuberculosis)
Brucella pinnipedialis	Brucellosis	Neurological and reproductive disorders	Sinusitis, lethargy, neurobacillosis
Bisgaardia hudsonesis	Seal finger	Unknown	Dermatitis
Erysipelothrix rhusipathiae	Erysipeloid (humans), erysipelas (marine mammals)	Rhomboid skin lesions, sepsis	Localised dermatitis, sepsis
Leptospira interrogans	Leptospirosis	Renal failure	Renal failure
Virus			
Pox virus	Pox virus infection	Dermatitis	Single papule, milker's nodule
Influenza virus subtypes A	Influenza	Pneumonia	Conjuctivits
Calcivirus (San Miguel Sea lion virus)	Calcivirus infection	Vesicular dermatitis	And influenza like symptoms
Fungi			
Ajellomyces dermatitidis	Blastomycosis	Granulomatous lesions in lungs and other organs	Lymphadenitis and cellulitis
Protozoans			
Toxoplasma gondii	Toxoplasmosis	Neurological signs, lethargy, weight loss	Fever, malaise, lymphadenopathy, abortion and still birth in pregnant women
Giardia spp.	Giardiasis	Dairrhea, weight loss	Malaise, abdominal cramps, watery diarrhea, nausea
Trichinella spp.	Trichinellosis	Muscle tenderness, myalgia (diaphragm, intercoastal and rear flipper muscle)	Fever, diarrhea, abdominal pain, vomiting, periorbital or facial edema, myalgia

Bacterial Zoonoses

'Seal-finger'

It is also known as spekk or speck finger or blubber's disease and is a zoonotic skin infection in sealers which is caused by *Mycoplasma* spp. present in the mouth and on the skin of pinnipeds (Baker *et al*., 1998; Hartley and Pitcher, 2002). A report states that a trainer from the New England aquarium got 'seal-finger' disease caused by *Mycoplasma phocicerebrale* due to seal bite (Baker *et al*., 1998). One other study showed that zoonotic transmission of *Bisgaardia hudsonensis* due to seal bites caused 'seal-finger' in a fisherman

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(Sundeep and Cleeve, 2011). *Bisgaardia hudsonensis* is a recently isolated gram-negative bacterium from Family Pateurellaceae (Foster *et al.*, 2011). Occupational exposure of sealers and marine mammal trainers to seals commonly causes *Mycoplasma* associated 'seal-finger' disease (Hunt *et al.*, 2008). Transmission of the disease usually occurs through physical trauma (e.g. seal bite), or by direct contact with infected marine mammal tissues.

Mycobacteriosis

Bacterium from Mycobacterium sp. group, *Mycobacterium pinnipedii* causes notable disease in pinnipeds and sporadic disease in humans and other terrestrial animals (Kiers *et al*., 2008; Moser *et al*., 2008; Kriz *et al.*, 2011). Transmission of *Mycobacterium pinnipedii* to humans may occur via direct contact with aerosols, mucosal secretions, feces or urine of pinnipeds (Quinn and Markey, 2003) or by indirect contact with sea lions confirm the infection by *Mycobacterium pinnipedii* transmitted to them by those pinnipeds (Kiers *et al*., 2008). Another report tells about the evidence of *Mycobacterium pinnipedii* caused pulmonary tuberculosis in Australian seal trainer (Thompson *et al*., 1993). There is also a report of *Mycobacterium bovis* infection transmitted by a fur seal (*Arctocephalus forsteri*) in both an oceanarium worker and a seal trainer from New Zealand (Thompson *et al*., 1993).

Brucellosis

The zoonotic infection of *Brucella* spp. transmission to humans by pinnipeds cannot be neglected due to presence of sporadic cases. Brew *et al*. (1997) confirmed the *Brucella* spp. transmission in a laboratory worker who was handler of infected seal tissue. Two neurobacillosis cases caused by *B. pinnipedalis* (seal strain) from Peru were reported with severe central nervous system infection and cerebral granuloma (Sohn *et al*., 2003). Bacteriological cultured have shown positive results for *B. pinnipedalis* in the hooded seal (*Cystophora cristata*), grey seal (*Halichoerus grypus*) (Foster *et al*., 1996). Pacific harbour seal (*Phoca vitulina richardsi*) (Garner *et al*., 1997), ringed seal (*Phoca hispida*) and harp seal (*Phoca groenlandica*) (Forbes *et al*., 2000, Maratea *et al*., 2003) which is already a proven zoonotic pathogen for humans.

Erysipelas

It is a bacterial zoonotic pathogen related to pinnipeds, is gram-positive bacillus in the Family Erysipelotrichaceae called as *Erysipelothrix rhusiopathiae* (Quinn and Markey, 2003) which infects a variety of domesticated and wildlife species (Wang *et al*., 2010) including humans, *Erysipelothrix rhusiopathiae* causes erysipelas or 'diamond skin disease' in animals and erysipeloids in humans. This bacterium is transferred from pinnipeds to humans via direct contact, necropsy and physical wounds caused by pinniped bitting (Hunt *et al.*, 2008; Chastel *et al*., 1975; Suer and Verdos, 1988).

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Leptospirosis

Leptospira spp. are gram-negative bacteria from the Family Leptospiraceae (Bharti *et al*., 2003) which infects several pinniped species as well as humans (Smith *et al*., 1977; Gulland *et al.*, 1996; Stamper *et al*., 1998; Colegrove *et al*., 2005). Detection of *Leptospira* from beach sand polluted by feces and urine of California sea lions, confirms the risk of transfer of this zoonotic bacterium to humans via environmental exposure (Cameron *et al*., 2008). Although, till date only a few cases of human leptospirosis have been confirmed due to pinniped transmission, the zoonotic potential regarding this transmission can be neglected (Smith *et al*., 1978; Hunt *et al.*, 2008). There are reports of Leptospiral transmission to humans via direct contact with the contaminated fluids and tissue during necropsy of California sea lion (Smith *et al*., 1978). Furthermore, a report from California showed that three researchers acquired *Leptospira* infection from California sea lion (*Zalophus californianus*) which caused acute nephritis and consequently led to renal failure in them (Baker *et al*., 1998).

Salmonellosis, Staphylococcosis and Vibriosis

Salmonella outbreaks have been observed in Arctic and Australian residents, who eat pinniped meat in their traditional diet (Cawthorn, 1997; Tryland, 2002). Vocational contacts with pinnipeds have resulted in sporadic *Staphylococcus aureus* and *Vibrio parahemolyticus* infections in humans (Palmer *et al*., 1998; Cowan *et al*., 2001).

The above-mentioned reports undoubtly confirm the zoonotic potential of pinnipeds for transmitting various bacterial zoonotic pathogens to humans. Workers in wildlife rehabilitation centers such as veterinarians, researchers, animal trainers and volunteers are certainly at a higher risk of zoonotic diseases transmitted by pinnipeds. Moreover, vocational contacts of humans with infected pinnipeds, much more increase the risk of zoonotic infections by these animals and causes a threat of infectious disease emergence. Pinnipeds rehabilitation, their captive management, and the related research activities are few main associative factors for pinniped related zoonotic disease transmission (Hunt *et al*., 2008).

Viral Zoonoses

Pox Virus Infection

Pinniped poxviruses are zoonotic viruses which are members of genus Para poxvirus (Hicks and Worthy, 1987; Clark *et al*., 2005) and are transmitted by humans by direct contact (Hicks and Worthy, 1987) or contact via physical trauma (Clark *et al*., 2005). A report shows that transmission of seal pox virus in three marine mammal technicians due to exposure to grey seals, in which single papule, 'milker's nodule', was seen on the hands of the technicians. These lesions are similar to the lesions caused by other zoonotic parapoxviruses like bovine papular stomatitis virus, pseudocow pox virus, Orf virus (Hicks and Worthy, 1987; Clark *et al*., 2005; Hunt *et al*., 2008) and seal pox virus.

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Influenza Virus

Influenza viruses are single-stranded RNA viruses from family Orthomyxoviridae out of which influenza A virus has been significantly reported in pinnipeds along the New England coast (Geraci *et al*., 1982; Hinshaw *et al*., 1984). Direct contact with infected harbour seal carcasses and with symptomatic animals is the primary cause of zoonotic transmission (Webster *et al*., 1981). A report shows that four people developed conjunctivitis who conducted post-mortem of H7N7-infected seals in an outbreak in New England (Webster *et al*., 1981). Another report shows the transmission of Influenza virus in an investigator who developed a sever conjunctivitis when an experimentally infected seal sneezed directly into his face (Webster *et al*., 1981).

Calcivirus Infection

San Miguel Sea lion virus (SMSV) is a single stranded RNA Calcivirus from the genus Vesivirus which has a wide host range from fishes, amphibians, and reptiles to mammals (Smith *et al*., 1980). SMSV is the precedent of feline Calcivirus which causes haemorrhagic fever in cats causing heavy mortalities (Ossiboff *et al*., 2007). Pinniped Calciviruses are either transmitted by direct contact or by consumption of contaminated pinniped meat (Smith *et al*., 1998). A report about accidental exposure of a researcher to SMSV serotype 5 in the laboratory proves the zoonotic potential of pinniped Calciviruses (Smith *et al*., 1998). A study about seroprevalence of SMSV in 765 human blood donors in Northwestern USA shows that 12 % of healthy blood donors were seropositive for SMSV (Smith *et al*., 2006).

Mycotic Zoonoses

Blastomycosis

Ajellomyces (Blastomyces) dermatitidis is a saprophytic dimorphic fungus from the family Ajellomycetaceae which is endemic in Eastern United States and Canada causing blastomycosis. Inhalation is the primary route of infection in humans and animals (Migaki and Jones, 1983). There are reports of blastomycosis in Stellar sea lions and California sea lions (Zwick *et al.,* 2000). Direct animal-to-animal transmission is uncommon because fungus is transmitted through inhalation of spores from contaminated environment (Bradsher *et al*., 2003).

Endoparasitic Zoonoses

Toxoplasmosis

Toxoplasma gondii is a zoonotic protozoal parasite of cats (Urquhart *et al*., 1987). Clinical toxoplasmosis is shown in a lot of autopsy reports of wild seals and dolphins (Taylor *et al*., 1985; Inskeep *et al*., 1990; Migaki *et al*., 1990; DiGuardo *et al*., 1995). Toxoplasmosis is found to be endemic in women in Northern

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Quebec, Canada with a seroprevalence of almost 55%. A report about 22 Inuit women showed that women eating dried seal meat were having four times higher antibody levels and women eating seal liver were having six times higher antibody levels against *T. gondii* as compared to seronegative women (McDonald *et al*., 1990). Although the incidence of *Toxoplasma* infection is low in pinnipeds, the role of pinnipeds in the zoonotic transmission of *T. gondii* cannot be overlooked.

Giardiasis

Protozoans like *Giardia* are recognised to infect dogs, cats, rodents and ruminants including humans (Dau, 1981). A report in the Western arctic region of Canada showed the presence of *Giardia* cysts in intestinal contents of ringed seal (Olson *et al*., 1997) Another report from East Coast of Canada showed the presence of Giardia cysts in harp seals, grey seals (*Halichoerus grypus*) and a juvenile harbour seal (Measure and Olson, 1999). Reports of human giardiasis from Inuits on Baffin Island (Eaton and White, 1976) and from Northern communities in Alaska (Pugh, 1985; Dean *et al*., 1990) reveals that pinnipeds can be potential *Giardia* reservoirs.

Trichinellosis

Trichinella is a nematodal zoonotic parasite which is present worldwide with a very diverse host range. It is found in walrus (*Odobenus rosmarus*) who eats ringed (*Phoca hispida*) and bearded seals *(Erignathus barbatus*) (Fay, 1960; Kjos-Hansen, 1983; Moorhead *et al*., 1999). Reports show that *Trichinella* spp. are also found in bearded, ringed and harp seals (Thorshaug and Rosted, 1956; Rausch, 1970; Bessonov, 1974). A report about an epidemic in Disko Bay in West Greenland showed that 33 people died due to trichinellosis caused by eating meat of walrus and beluga whale (Thorborg *et al*., 1948). The walrus might get infected by eating seals and the seals might get infected by eating amphipods which might get infected by feeding on carrion on the sea bottom (Fay, 1960). Reports about two outbreaks of trichinellosis in Barrow in 1975-76 showed that they occurred due to the consumption of infected walrus meat (Margolis *et al*., 1979).

Significant public attractions and substantial significant research interests are kindled by pinnipeds. Due to these reasons, people coming in direct or indirect contact with pinnipeds remain at a potential health risk related to zoonotic disease transmitted by pinnipeds. Most of the skin related zoonotic disease transmitted by pinnipeds to humans like 'seal-finger', are cured with suitable medical treatment. But other zoonotic diseases transmitted by pinnipeds to humans may cause life-threatening systematic complications, which if left untreated may cause death of the person. The diagnosis and treatment of these emerging zoonotic pathogens transmitted by pinnipeds have become challenging as the number of the zoonotic pathogens is increasing. We brought an inclusive review of the bacterial, viral, fungal, endoparasitic zoonotic diseases transmitted by pinnipeds which can be used by public health professionals, physicians, veterinarians,

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wildlife personnel, and general public to better perceive, detect and prevent the zoonotic diseases transmitted by pinnipeds.

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