Antibiotic-Resistant in Scavenger birds: a One Health Problem

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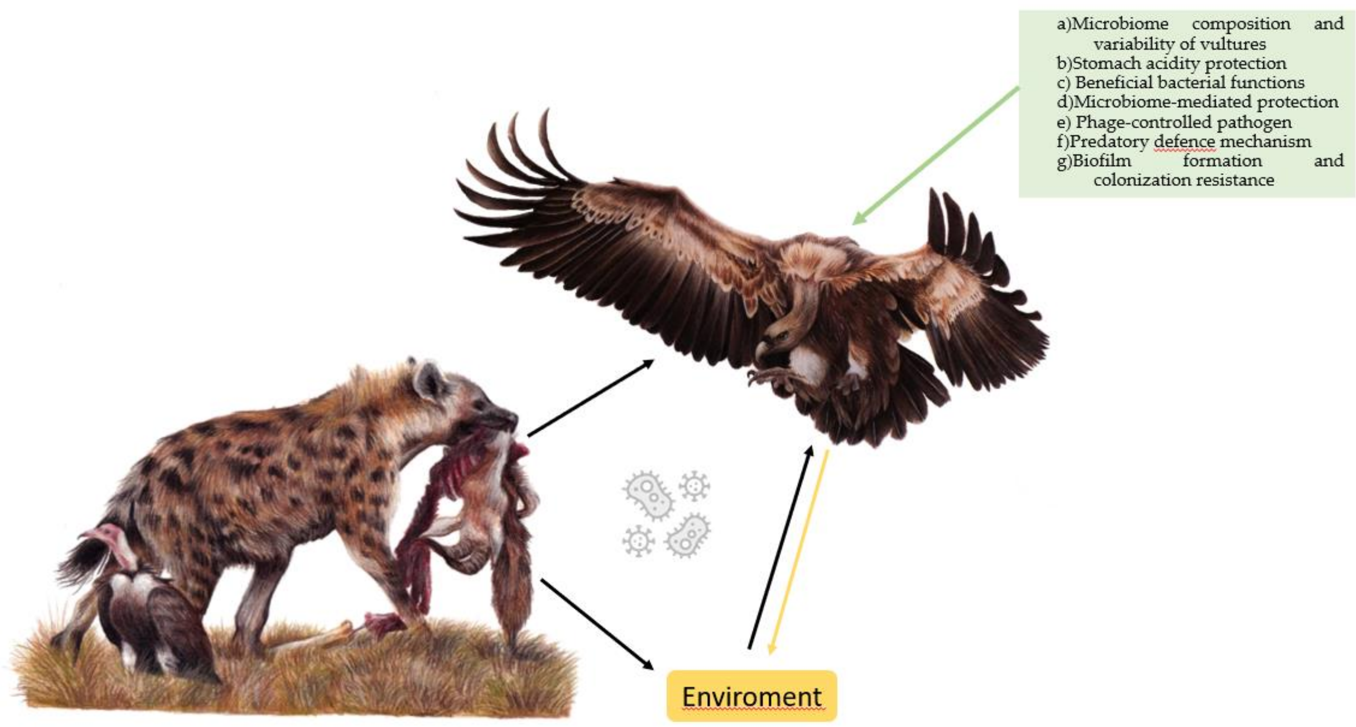
Introduction

Vultures are composed of two great groups the New World vultures (Cathartidae) and Old-World vultures (Accipitridae). Vulture populations are in decline worldwide. Collisions with wind-energy turbines, electrocution, poisoning, and ingestion of lead from carcasses or gunshots are some of the causes associated to this decline. According to the IUCN Red List species such as *Sarcogyps calvus*, *Gyps africanus*, *Trigonoceps occipitalis* or *Gyps rueppelli* are Critically Endangered. On the other hand, through the conservation efforts of many ONG and governmental entities, populations of *Coragyps atratus* and *Gymnogyps californianus* have been increasing in recent years.

Vultures have a fundamental role in the ecosystem. They are known as "nature's cleanup crew" because they feed on animal carcasses that have died from old age, malnutrition, accidents, predation, or diseases. These carcasses left in the environment could have become an important health risk for animals and humans. Vultures help to remove the organic material from the environment, and therefore help to reduce the spread of pathogenic microorganisms in the ecosystem. However, despite the serious health effects of consuming these carcasses, vultures have developed important adaptations to deal with these agents.



If the vultures disappeared, the uneaten carcasses would remain in the environment for longer periods, and facultative scavenger species such as dogs and rats would take advantage of this food source. These opportunistic species, some considered pests, would increase in abundance and associated zoonotic diseases (e.g., Leptospira, rabies, plague). Furthermore, the longer the carcass remains in the environment, the greater the likelihood of contact with humans and spread of pathogens. The conversion of wild territories to agriculture has been associated with shifts in food resources available to avian scavengers. Some populations have increased dependence on domestic animal carrion and farm waste. Regular consumption of livestock remains can expose scavenging birds to veterinary drug residues. Studies carried out in India and in other countries have shown the presence of diclofenac residues in vulture tissues associated with the consumption of carcasses contaminated with this drug. Consumption of this compound led to the death of several vultures.

The aim of this study is to compiled some of the most recent studies on antibiotic resistance reported on vulture species.

Results

Overall, we analysed a total of 20 works, between the years 2011 to 2021. The studies were performed on *Cathartes aura* (n=1), *Gyps Bengalensis* (n=1) *Neophron percnopterus majorensis* (n=3), *Neophron percnopterus percnopterus* (n=3), *Gyps fulvus* (n=5), *Aegypius monachus* (n=4). Two studies were performed simultaneous forseveral species.

The predominant sample type was faecal material in almost all paper, except one.

The countries with the highest number of studiesin descending order as follows: Spain (n=11), India (n=3), the USA, Germany, Mongolia, and Portugal (n=1).

Since most studies were performed on faecal samples, the isolated bacteria were mostly microbiota faecal flora microbiota, with *Escherichia coli* one of most studied microorganisms (n=12). Extended Spectrum Beta-Lactamase was detected in 5 different studies. The main resistance present in E.coli were ampicillin, tetracycline and sulfamethoxazole-trimethoprim.

Table 1. Studies describing the presence of AMR in different vultures regarding the specie, conservation status, number, year, country, agent isolated, resistances and genes.

Specie	Conservation status	N	Year	Country	Type sample	Bacteria isolated	Resistance	Resistance Gene
Turkey vultures (*Cathartes aura*)	Least concern	55	2014	USA	Faecal	*E. coli*	Tetraciclyne (24%), ampicillin (3%), gentamicine (7%)	-
Canarian Egyptian Vultures (*Neophron percnopterus majorensis*)	Endangered	142	2017	Spain	Faecal	*E. coli*	39.8% MDR *E. coli*, chloramphenicol (n=13) imipenem (n=5)	-
		142	2015-2017	Spain	Faecal	*Salmonella spp., Proteus mirabilis, Providencia rettgeri, P. stuartii, Klebsiella pneumoniae, K. oxytoca, Raoultella ornithinolytica, Citrobacter braakii.*	Ampicillin (54.25%), tetracycline (48.44%), trimethoprim/sulfamethoxazole (46.85), cefpodoxime (3.1%), polymyxin B (3.7%), nitrofurantoin (6.15%).	-
		22	2019	Spain	Faecal	*E. coli*	Cefotaxime (n=5), ESBL (22.7%)	blaCTX-M-15 (n=3), blaCTX-M-55 (n=2), blaTEM gene (n=3), tetA (n=1).
Egyptian vultures (*Neophron percnopterus percnopterus*)	Endangered	25	2011	India	Faecal	*K. pneumoniae*	Beta-lactams, glycopeptides, macrolides, polypeptides, sulfonamides groups	K5 serotype
		25	2011-2012	India	Faecal	*Pseudomonas aeruginosa*	Ampicillin, bacitracin, carbenicillin, cephalothin, colistin, kanamycin, cefotaxime, nalidixic acid, nitrofurantoin	-
		38	2021	India	Faecal	*E. coli*	cefotaxime (56.65%), amoxiclav (43.33%)	-
Griffon vultures (*Gyps fulvus*)	Least Concern	104	2016	Spain	Faecal	*E. coli*	tetracycline and streptomycin (>70%), for ampicillin and sulfamethoxazole-trimethoprim (>50%), colistin (2.2%), extended-spectrum cephalosporins (1.1%), 80% MRD	blaSHV-12 (n=3), mcr-1 (n=2), aadA1, aadA2, cmlA1 and sul3 (n=1)
		104	2016	Spain	Faecal	*Clostridioides difficile*	Ciprofloxacin (100%), moxifloxacin (66.6%), erythromycin (33.3%)	tcdA, tcdB, cdtA and cdtB.
		10	2011	Spain	Faecal	*E. coli*	Ampicillin, cotrimoxazole	fimH, fimAvMT78, iroN, iucD, cvaC, iss, traT and tsh
		218	2019-2020	Spain	Faecal	*Salmonella spp, S. Typhimurium, Campylobacter lari*	tetracycline (52 %) and ampicillin (48 %), trimethoprim (10.5 %), ciprofloxacin, nalidixic acid, chloramphenicol gentamicin (5.2 %)	-
		14	2013-2014	Spain	Faecal	*E. coli*	ESBL (n=14)	CTX-M-1(n=1) 2, SHV-12 (n=2)
		40	2008-2011	Spain	Faecal	*Staphylococcus aureus*	MRSA	-
Oriental White Backed Vulture (*Gyps Bengalensis*)	Critically endangered	1	2012	India	Blood and faecal	*E. coli*	Penicillin, ampicillin, and amoxicillin	-
Cinereous vulture (*Aegypius monachus*)	Near Threatened	324	2015-2016	Spain	Traqueal	*Staphylococcus aureus, S. delphini*	MRSA (n=13), *S. delphini* penicillin (75%, with blaZ gene) and tetracycline [58%, with tet(K)± tet(L)],	mecC (n=12), mecA, lukS/F-PV, tst, eta, etb, etd (n=13), scn, sak (n=4), lukS-I, siet, seint (n=11), lnu(A) (n=4)
		2	2008	Portugal	Faecal	*E. coli*	ESBL (n=1), ampicillin, nalidixic acid, ciprofloxacin, streptomycin, chloramphenicol, sulfamethoxazole-trimethoprim	blaCTX-M-1, blaTEM-1b, sul1, sul2
		30	2010	Germany and Mongolia	Faecal	*E. coli*	ESBL (n=1)	blaCTX-M-9, sul2, strA, strB, integron class I, blaTEM-1-like, blaOXA-1, tet(A), sul2, strA,strB, aac (69)-IB-cr, integron class I
Gyps fulvus, Aegypius monachus	-	12	2015-2016	Spain	Faecal	*E. coli, K. pneumonia*	ESBL	CTX-M-1 (n=3), CTX-M-9 (n=3), CTX-M-1 (n=2), SHV (n=1), mcr-1 (n=1)
Gyps fulvus, Neophron percnopterus	-	66	2016	Spain	Faecal	*E. coli, Enterobacteriaceae,*	ESBL (25-30%),	CTX-M-1, qnrS
		66	2016	Spain	Faecal	*Enterococcus faecalis, E. durans, E. faecium, E. avium, E. hirae*	Ciprofloxacin-resistant E. faecium (20.8%), linezolid-resistant E. faecium (n=1)	-
		114	2016	Spain	Faecal	*Salmonella spp.*	Ampicillin, amoxicillin, streptomycin (95.7%), neomycin (82.6%	-

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Conclusions

Antimicrobial resistance is a "One Health" issue. The problem of multidrug-resistant bacteria is associated with human and veterinary medicine. Consequently, the detection of multidrug resistant bacteria important, due to the continuous interaction between domestic animals, humans, ecosystem and wild animals.

Regarding antimicrobial resistance, vultures can be important as sentinels, reservoirs, spreaders, and sources of infection for humans, other animals, and the ecosystem. Although vultures play an important role in the ecosystem as cleaners for the environment and therefore limiting the spread of pathogenic microorganisms, they can acquire AMR bacteria and spread them. Furthermore, they can act as an asymptomatic reservoir for zoonotic bacteria (e.g., *Salmonella*) and other agents. These microorganisms can represent a potential threat to the conservation of vulture populations, since they can produce disease in individuals. More survey studies on AMR and pathogens are needed in these populations, some of them so threatened.

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