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A Systematic Review on Prevalence of Extended-Spectrum Beta-lactamase in Animals and Animal derived food in India

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Abstract:- Extended spectrum beta-lactamase (ESBL) producing bacteria becomes a serious worldwide public threat. ESBL is not just limited to human health sector but also encounter animals and environment. This review article tries to summarise overall prevalence of ESBL among food producing animals and animal derived food in India. It also specified zone-wise prevalence of ESBL producing bacteria with genes related to ESBL. Systematic search from Google Scholar and PubMed was performed to find out ESBL related articles from 2013 to September 2021. Analysis of eligible 28 articles showed higher prevalence of ESBL in north-eastern region of India. The species wise study results showed a higher occurrence of ESBL producing *E. coli*, followed by *K. pneumoniae*. This study on prevalence of ESBL in animals could be useful in planning of nationalise approach in decreasing burden of antimicrobial resistance and management of antibiotics in animals.

I. INTRODUCTION

Antimicrobial resistance (AMR)is a well-recognised multifaceted global threat to public health, especially in Asian region prevalence of AMR is sporadic and widespread (Bhardwaj *et al*., 2021). Intercontinental transmission of AMR microbes among people and animals increased in last two decade as ease of movement increase (Koovapra*et al*., 2016). These antibiotic-hydrolysing enzyme producers has increase morbidity, mortality and fiscal burden, this situation is worsened in developing country like India where lack of research on the subject, overuse and underuse of antibiotics, practice of taking medicine without prescription, absence of strict laws is there (Gida *et al*., 2020). India, situated in southern part of Asia, marks a very high number of AMR not only in humans but also in livestock due to unhygienic conditions, poor screening and not specific regulation with proper implementation (Bhattacharyya *et al*., 2020).

Extended spectrum beta-lactamase are group of plasmid mediated enzymes produced by microbes to confer resistance against third generation cephalosporins and aztreonam but are inhibited by clavulanic acid (Shrivastav *et al*., 2016). Beta-lactam antibiotics are mostly used antibiotics to treat bacterial infections, so natural selection and adaptation of bacteria to gives rise to resistance specially against these antibiotics. Gram-negative bacteria like *E. coli* and *K. pneumoniae* are major producers of ESBL, although *Pseudomonas aeruginosa*, *Proteus mirabilis*, *Enterobacter spp*., *Acinetobacter spp*. also produce ESBL (Das *et al*., 2020).Healthy animals without any disease symptoms becoming reservoir of ESBL-producing bacteria so there is an urgent need of nationalise screening of these multidrug resistant bacteria (Kalaiselvi *et al*., 2018). A surveillance system required for regulating the consumption of antibiotics in livestock and minimize natural selection of resistant bacteria.However, following the Global Action Plan initiated by World Health Organisation, Indian government launch a five-year National Action Plan in April 2017 for curbing AMR in India. This plan encompasses human-health sector, environment and food-animal sector. *(NAP-AMR-2017).*

In this study we compile the research data from 2013 to 2021 on prevalence of ESBL in animals.

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Author and year of publication	State	Sample type	Number of ESBL positive samples/Total number of samples (% prevalence)	Methodology	ESBL Gene Type	ESBL producing species
			Northern Zone			
Chauhan *et al*., 2013	Himachal Pradesh	Raw milk samples	27/100 (27%)	Double disc diffusion method	-	*K. pneumoniae*
Sharma et al., 2021	Jammu and Kashmir	Faecal samples from poultry	150/400	DDST	TEM, CTX, SHV	*E. coli*
Brower et al., 2017	Punjab	cloacal samples from poultry	330/510	VITEK	-	*E. coli, K. pneumoniae, E. fergusonii, P. mirabilis, E. hermannii*
Devi et al., 2020	Haryana	Livestock manure	576/1080 (53.33%)	Double disk diffusion test	CTX-M	*E. coli and K. pneumoniae*
			North Eastern Zone			
Lalzampuia*et al*., 2013	Mizoram	Fecal samples of pigs	7/138 (5.07%)	PCR based detection	-	*E. coli*
Lalzampuia*et al*., 2013	Mizoram	Fecal samples of pigs	7/138 (5.07%)	PCR based detection	-	*E. coli*
Lalzampuia et al., 2013	Mizoram	Fecal samples of poultry birds	1/11 (9.09%)	PCR based detection	-	*E. coli*
Lalzampuia et al., 2014	Mizoram	Faecal samples of poultry birds	7/134 (5.22%)	DDST	CTX-M-1, TEM	*E. coli, Salmonella spp. and K. pneumoniae,*
Deka and Ahmed 2021	Guwahati (Assam)	Poultry	32/98 (32.65%)	Double disc diffusion	-	*E. coli*
Sivaraman et al., 2021	Assam	Fish	66/79 (83.54%)	BD Phoenix ESBL screening test	CTX-M-15, TEM, SHV, OXA-1-like,	*E. coli* and *K. pneumoniae*
Koovapra et al., 2016	Mizoram	Bovine milk samples	6/103 (5.82)	Combination disc diffusion test and ESBL Etest	CTX-M, TEM and SHV	*K. pneumoniae*
Borah et al., 2014	Assam	Cow dung	28/80 (35%)	Disk diffusion test	CTX-M, TEM, SHV, AmpC	*E. coli*
Tewari et al., 2018	Assam	Fecal samples of livestock	10/48 (20.83%)	PCR-based detection	-	*E. coli*
Tewari et al., 2018	Assam and Meghalaya	Faecal samples of livestock	24/32 (75%)	PCR-based detection	-	*E. coli*
Sivaraman et al., 2020	Assam	Fish Samples	54/79 (68.35%)	Multiplex PCR	CTX-M-15	*E. coli, K. pneumoniae,*
Das et al., 2020	Assam	Raw milk of cattle	51/ 209 (24.4%)	CDT and E-test	CTX-M, TEM, SHV	*E. coli and K. pneumoniae*
Das et al., 2020	Assam	Curd of cattle	1/12 (8.33%)	CDT and E-test	CTX-M, TEM, SHV	*E. coli*
Das et al., 2020	Assam	Chicken meat	7/32 (21.87%)	CDT and E-test	CTX-M, TEM, SHV	*E. coli and K. pneumoniae*

Das et al., 2020	Assam	Pork meat	1/15 (6.67%)	CDT and E-test	CTX-M, TEM, SHV	*E. coli*
Das et al., 2020	Assam	Cattle faeces	27/69 (39.13%)	CDT and E-test	CTX-M, TEM, SHV	*E. coli and K. pneumoniae*
Central Zone						
Bhoomika et al., 2016	Chhattisgarh	Raw milk	6/73(8.22%)	Multiplex-polymerase chain reaction for detection	TEM, SHV, and CTX-M	*E. coli*
Shrivastav et al., 2016	Madhya Pradesh	Caecal swab samples in healthy broilers	135/400 (33.75%)	Combined disc diffusion test, DDST, Enz MIC strip ESBL	-	*E. coli*
Dewangan et al., 2017	Chhattisgarh	Chevon meat	8/126 (6.35%)	Phenotypic detection of	-	*E. coli*
Dewangan et al., 2017	Chhattisgarh	Raw milk	8/104 (7.69%)	Phenotypic detection of	-	*E. coli*
Nirupama et al., 2018	Uttar Pradesh	Fecal samples of pigs	243/741(32.79%)	Double disc diffusion method and Hi-comb MIC test strip ESBL	-	*E. coli*
Sivakumar et al., 2020	Uttar Pradesh	Food and environment	22/316 (6.99%)	Combined disk diffusion test and E-test	CTX-M, TEM, OXA-1	*E. coli*
Agarwal et al., 2021	Uttar Pradesh	Uterine infection in dairy cattle	39/40 (97.5%)	Epsilometer test	CTX-M, TEM and SHV	*E. coli*
Eastern Zone						
Koovapra et al., 2016	Jharkhand	Bovine milk samples	10/78 (12.82%)	Combination disc diffusion test and ESBL Etest	CTX-M, TEM and SHV	*K. pneumoniae*
Das et al., 2017	West Bengal	Milk samples of subclinical mastitis infected cattle	24/50 (48%)	PCR based detection	CTX-M, TEM	*E. coli, Proteus, Pseudomonas, Klebsiella,* and *Enterobacter*
Mahanti et al., 2017	West Bengal	Cloacal swabs from healthy broiler, indigenous, and kuroiler birds	33/307 (10.75%)	PCR-based detection	TEM, SHV, CTX-M	*K. pneumoniae*
Bhattacharyya et al., 2020	West Bengal	Water sample	8/21 (38%)	Double disk diffusion test	CTX-M, TEM, NDM	*K. oxytoca*
Banerjee et al., 2020	West Bengal	Rectal swab of Dog	56/111 (50.4%)	DDST	CTX-M, TEM, SHV	*Klebsiella*
Banerjee et al., 2020	West Bengal	Rectal swab of Cat	16/39 (41%)	DDST	CTX-M, TEM, SHV	*Klebsiella*
Banerjee et al., 2020	West Bengal	Rectal swab of Sheep	12/34 (35.29%)	DDST	CTX-M, TEM,	*Klebsiella*

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					SHV	
Banerjee et al., 2020	West Bengal	Rectal swab of goat	9/27 (33.33%)	DDST	CTX-M, TEM, SHV	*Klebsiella*
Batabyal et al., 2020	West Bengal	Bovine faecal samples	3/21 (61.9%)	DDST	CTX-M. SHV, AmpC	*E. coli*
Western Zone						
Barad et al., 2019	Gujrat	cloacal swabs form broiler	27/126 (21.43%)	Double disk diffusion test	TEM, AmpC	*E. coli*
Gida et al., 2020	Gujrat	Chicken muscle sample	25/92 (27.17%)	E-test	CTX-M-3, SHV	*E. coli*
Southern Zone						
Bhardwaj *et al.*, 2021	Karnataka	chicken cloacal swab	11/207 (5.31%)	Double disc diffusion test	qnrS and qnrA	*E. coli* and *K. pneumoniae*
Naidu *et al.*, 2021	Andhra Pradesh	Foods of Animal origin and chicken cloacal swab	55/68 (80.88%)	-	TEM, CTX, OXA, DHA and CIT	*E. coli*

Table 1

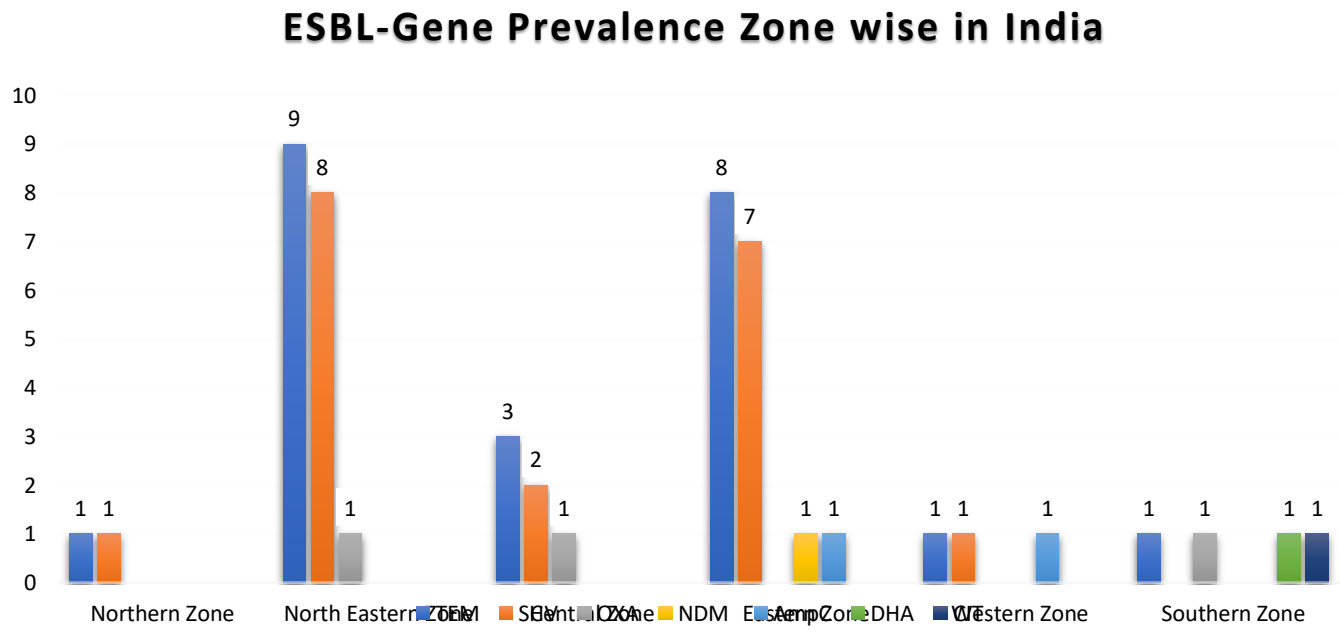

Fig. 1

Zones	No. of Studies	CTX	TEM	SHV	OXA	AmpC	NDM	DHA	CIT	qnrS	qnrA
Northern Zone	**4**	**2**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
North Eastern Zone	**16**	**10**	**9**	**8**	**1**	**-**	**-**	**-**	**-**	**-**	**-**
Central Zone	**7**	**3**	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**
Eastern Zone	**9**	**9**	**8**	**7**	**-**	**1**	**1**	**-**	**-**	**-**	**-**
Western Zone	**2**	**1**	**1**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**-**
Southern Zone	**2**	**1**	**1**	**-**	**1**	**-**	**-**	**1**	**1**	**1**	**1**

Table 2

II. CONCLUSION

The high prevalence of ESBL-producing bacteria were found in this study which clearly shows the potential risk of transmission of these AMR strains to humans. A high diversity of ESBL genes such as CTX, TEM, SHV, OXA, DHA etc. were detected all over the country. Most prevalent

ESBL-producing bacteria were *E. coli* and *K. pneumoniae*. Diverse strains of *E. coli* having more antibiotic resistance were also detected. In most of studies healthy animals containing AMR bacteria were detected which misguide the terrible situation of AMR in livestock. Future research should focus on identifying the drivers responsible for the acquisition and dissemination of ESBL in companion animals including cross-species transmission with humans and livestock, the clinical relevance of these bacteria and their economic impact.

This scoping review identified the prevalence and population structure of ESBLisolates circulating in animals and environment. Many studies were excluded due to incomplete or inadequate reporting of data. This review also calls for the establishment of national surveillance programs in low- and middle-income countries that will allow monitoring the extension of the ESBL problem in companion animals and evaluate the implementation of different strategies to limit the spread of ESBL including more responsible use of antibiotics by both veterinarians and owners.

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