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Review: Ethno-zoological study of animals-based medicine used by traditional healers of Northeast India

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Abstract. *Hussain JF, Tynsong H. 2021. Review: Ethno-zoological study of animals-based medicine used by traditional healers of Northeast India. Asian J Ethnobiol 4: 1-22.* For ages, plants and animals have been used in human cultures as therapeutics. Animals have not only acted as a source of food for humans but have also been commonly used in applications such as medicine, clothes, and other related services. The use of animals and animal products in traditional methods of treating diseases, and for many different reasons, dates back to the early days of civilization. Treatment of human diseases using animal-derived products is called zootherapy or ethno-zoology. Despite the worldwide utilization of ethno-zoology in the form of traditional medicines based on animals, a thorough study of zootherapy in comparison to plant-based medicinal research is still ignored. This study highlights available knowledge on ethno-zoological therapeutic applications used by different traditional healers of North-East (NE) India. Concerning the frequency of animal species, the use of mammals and mammalian products is the highest in NE India compared to other animal groups. In contrast, the use of fish-based medicine in the state of Manipur is prevalent compared to other animal species. In Arunachal Pradesh, the use of insects is high in traditional medicines.

Keywords: Animals-based medicines, ethno-zoology, North-East India, traditional knowledge

INTRODUCTION

The treatment of human diseases using animals and animal-derived treatments is known as zoo therapy (Costa-Neto 1999). World Health Organisation (WHO 1993) reported that around 70-80% of the world's rural population relies for primary health care on traditional medicine. Using animals and their products to treat patients suffering from various health problems has a long tradition. It is still prevalent in many parts of the world, even when medical science has achieved great heights (Jugli et al., 2019). WHO (2014) estimates that in developing countries, the proportion of the population using traditional medicine is considerably higher (60-90%) compared to developed countries (23-80%).

Knowledge of traditional medicines by indigenous communities worldwide that help them heal, avoid, and mitigate diseases is derived from their cultural traditions, indigenous values, ideas, and rituals (Young 1983; Janes 1999). Animal-based treatments are successful in several applications, and in recent times, they constitute a significant part of traditional pharmaceutical products (WRI 2000). Anageletti et al. (1992) and Rosner (1992) reported that animals and their products had been used internationally in traditional treatments, playing significant roles in healing practices, magic rituals, and religious practices amongst various cultures and communities.

Animal-based medicines are usually obtained from three sources: (i) the entire body or its smaller parts, (ii) metabolic products such as secretions or excreta, and (iii) other items produced by animals like nests, coconuts, honey, eggs, etc. (Costa-Neto 2005). In recent times, the application of zootherapy has been considered the foremost reliable primary alternative among many other known therapeutic practices in the world (Kendie et al., 2018). The traditional knowledge of indigenous people around the globe has played a crucial role in identifying living organisms endowed with medicinal values; and is essential for treating human health problems (Kendie et al. 2018).

Over several hundred years, communities and societies have slowly developed a large store of information on animals that could be closely combined with different aspects of cultures and customs, thereby providing new possibilities for other cultural strategies(Alves 2012). WHO has previously selected 252 essential chemicals for medicinal purposes, of which 11% are of plant origin, and 9% are of animal origin (Marques 1997). While this shows that traditional based medicines derived from plants and their derivatives have been studied in more detail (Werner 1970; Ragupathy et al. 2008; Ragupathy and Newmaster 2009; Polat et al. 2015; Silambarasan and Ayyanar 2015; Bhatti et al. 2017; Faruque et al. 2018), however, the identification of animal resources for medicinal and human health care is equally important and requires extensive research (Alves and Rosa 2005; Costa-Neto 2005).

India is home to large ethnic and indigenous communities (von Fürer-Haimendorf 1982) relying heavily on plants and animals for their medicine (Sarmah et al. 2006; Tynsong et al. 2006), food (Dutta and Dutta 2005; Tynsong et al. 2012a, b), shelter (Cavendish 2000),

clothing (Mao et al. 2009), etc. Borah and Prasad (2017) reported that many indigenous communities in India have recently begun opting for traditional animal-based medicines as an alternative to other health care systems. Animal by-products such as hooves, scales, bones, feathers, tusks, etc. have acted as essential ingredients for the preparation of some curative medicines and drugs (Adeola 1992; Anageletti et al. 1992; Kang and Phipps 2003). Documentation of the country's traditional methods of healing using animal-based medication is essential for establishing new medicinal prospects and remedial measures for several unknown diseases (Borah and Prasad 2017).

The Indian traditional knowledge system on medicine has declines due to the steady increase of urbanization and other anthropogenic factors (Das 2015). Therefore, it is vital to understand and record the knowledge available on animal-based therapeutics practiced by local healers among different indigenous communities before these traditional cultures and practices are forbidden and lost (Trivedi 2002). However, overexploitation of animals may jeopardize species' survival rate, causing ecosystem imbalances (Tynsong et al. 2020). Therefore, to preserve the proper harmonious life of humans and animals in the use of animal-based medicines, documentation is necessary to understand the everyday use of animals and animal products by local healers as a source of traditional therapy (Chakravorty et al. 2011a, b).

Studies on plant-based traditional medicine have been comparatively more in North-east (NE) India (Dutta and Dutta 2005; Sajem and Gossai 2006; Mao et al. 2009; Chakraborty et al. 2012; Prakash et al. 2014; Tynsong et al. 2020) compared to animal-based traditional medicines (Lalramnghinglova 1999). The lack of information is mainly because knowledge of animals-based traditional medicine is usually passed orally from one generation to the next, and this information is slowly lost as the knowledge bearers die (Borah and Prasad 2017). The present study is aimed to review and discuss the status of traditional animal-based medicines in NE India.

STUDY AREA

NE India is part of the Indo-Burma biodiversity hotspot and accounts for 8% (about 262,179 sq. km) of India's total geographic area (Tynsong et al. 2020). NE India has eight states, namely Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalaya, Nagaland, Tripura, and Sikkim (Figure 1). Arunachal Pradesh is a culturally rich state of NE, India, and is the largest (area-wise) with rich alpine geographical diversity and a wider variety of wildlife (Saio and Upadhyay 2018). NE India is considered a home to many indigenous communities and groups with varying social-cultural practices, following a wide variety of cultural diversity, and leading a life largely dependent on the biological resources around them (Ripunjoy and Indira 2012; Teron and Borthakur 2012).

Mao et al. (2009) recorded that NE India is inhabited by more than 200 indigenous communities with distinct cultural entities, the while the 2011 census reports that NE India is home to 427 tribal groups with their own traditional and cultural identities (Borah and Prasad 2017). These indigenous communities possess a wide range of traditional knowledge on traditional medicines (Tynsong et al. 2020). It is crucial to record such an information structure before it gets lost forever inside the rapid push of modernization and globalization. The number of significant and sub-indigenous communities in NE India as reported by various researchers is summarized in Table 1.

North-east India's indigenous people have long been dependent on traditional medicine for their overall health and wellbeing (Jamir and Lal 2005; Kalita et al. 2005; Mao et al. 2009; Tynsong et al. 2020). For example, Arunachal Pradesh's Nyishi and Galo communities use edible and therapeutic insects and vertebrate species to treat various ailments (Chakravorty et al. 2011a), while ethnic communities of Nagaland use different animals to treat asthma, tuberculosis, rheumatic pain, and paralysis (Jamir and Lal 2005). In Meghalaya, the use of animals for various ailments is recorded among the Khasi community in their natural, zoo-therapeutic traditional methods (Mihsill and Keshan 2017; Turnia and Prasad 2017). A wide variety of traditional plant-based medicines (Sajem and Gossai 2006), animals, and often mixed plant and animal formulations (Kalita et al. 2005) were recorded from the state of Assam. Ethno-zoological applications reported from Manipur, Sikkim, Mizoram, and Tripura are also discussed in this paper.

DATA ANALYSIS

Data sources

The present research work is focused on the original reports and findings and review papers. In this study, a survey of the initial investigations was mainly considered. The definitions are based on the authors' study of the knowledge on ethno-zoology available in NE India. Most of the literature has been cited/downloaded from journals and online sources such as Research Gate, Google Scholar, Academia.edu, and the respective journals' official websites. The IUCN Red List of Endangered Species (IUCN 2020) was used to determine the conservation status of the different animal species used for traditional medicine by various indigenous groups of NE India.

State-wise analysis

State-wise analysis in the results has been presented in alphabetical order according to the names of the North-Eastern Indian States. With the aid of Microsoft (MS) Excel, quantitative evaluation of data concerning the use of animal groups among different indigenous communities in NE India has been conducted. The analysis of the present paper was intended to include and incorporate the available knowledge recorded in NE India on traditional medicine using animals. The present report is based on the compilation of literature surveys of general knowledge on ethno-zoological activities prevalent in all eight North-east Indian states from 1999 to October 2020; and is discussed hereunder.

DETAILED REPORT OF EACH STATE

A survey on the available literature of ethno-zoological applications by traditional healers in all the Northeast Indian states has helped identify various animal groups used for medicinal purposes. A The present paper has discussed a detailed report on available literature pertaining to each state.

A summary of the available literature and research findings on ethno-zoological studies in NE India, with details of animal groups and their body parts used for several diseases, are presented in Table 2.

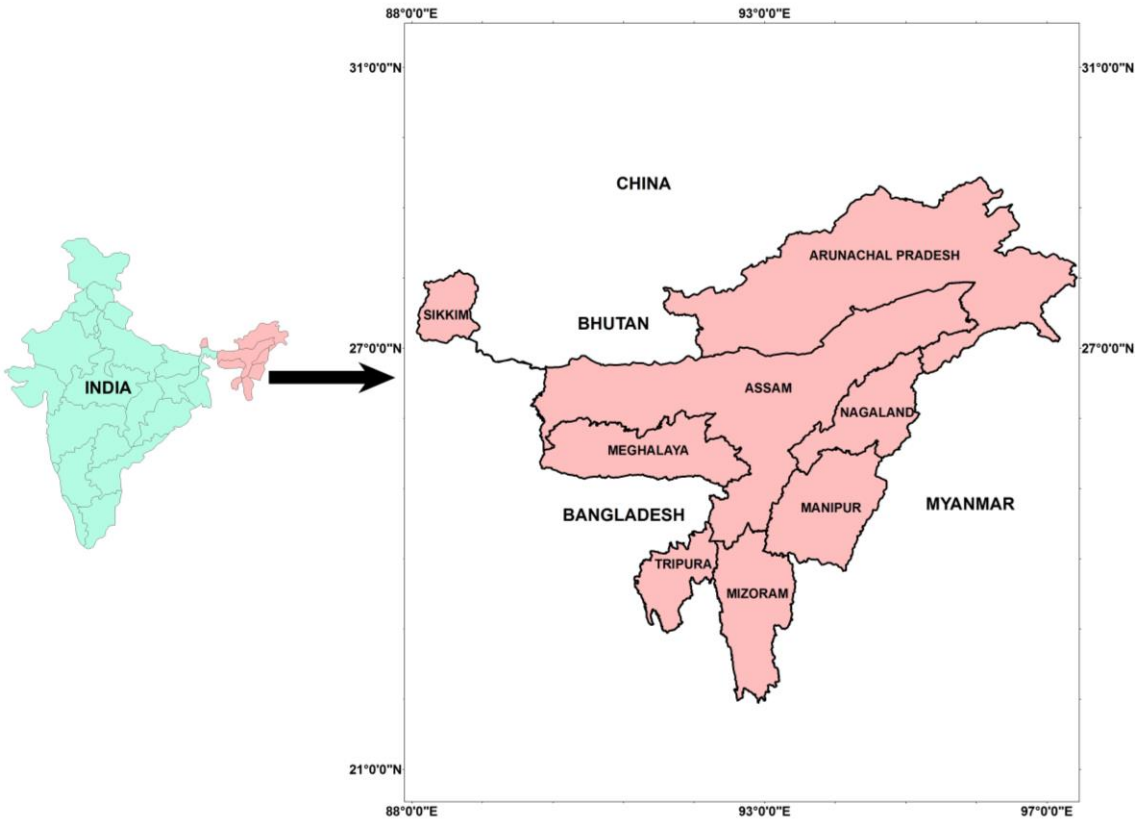

Figure 1. Location map of North-east India

Table 1. Number of major and sub-indigenous communities in North-east India as reported by various researchers

State	No. of major indigenous communities	No. of sub-indigenous communities	Referred literature(s)
Arunachal Pradesh	20	17	Dutta and Dutta (2005), Tynsong et al. (2020)
Assam	62	16	Dutta and Dutta (2005), Tynsong et al. (2020)
Manipur	29	-	Dutta and Dutta (2005), Tynsong et al. (2020)
Meghalaya	22	-	Dutta and Dutta (2005), Chakraborty et al. (2012), Tynsong et al. (2020)
Mizoram	15	45	Dutta and Dutta (2005), Chakraborty et al. (2012), Tynsong et al. (2020)
Nagaland	36	16	Chakraborty et al. (2012), Tynsong et al. (2020)
Sikkim	3	-	Dutta and Dutta (2005), Chakraborty et al. (2012), Dhakal et al. (2019)
Tripura	19	-	Chakraborty et al. (2012), Das (2015), Tynsong et al. (2020)

Note: '-' signifies not reported

Table 2. Ethno-zoological studies of animal groups and their body parts used for several diseases in NE India

State	Indigenous community	No. of animal species used	Body parts used	Ailments/Diseases	Author(s)
Arunachal Pradesh	Monpa	11 (mammals, birds)	Meat, gall bladder, bones, musk, musk gland of musk deer, fat.	Malaria, typhoid, tuberculosis, fever, rheumatic pain, diarrhea, smallpox, cholera, magico-religious purposes.	Solanki and Chutia (2004)
	Nyishi	13 (mammals, birds, reptiles)	Skin, claw, teeth, meat, musk, pod, tusk, gall bladder, fat.	Rheumatic pain, dysentery, jaundice, intestinal troubles, infections, liver and heart diseases, cough, hypertension, malarial fever, swelling, burn, joint fractures, impotency.	Solanki et al. (2004)
	Nyishi	18 (mammals, birds, reptiles)	Gall bladder, horn, penis, meat, bone, fat, testis, exoskeleton, alimentary canal.	Malaria, typhoid, dysentery, feminine problems, rheumatic pain, pox, wounds, abdominal pain, weakness.	Solanki et al. (2005)
	Galo	16 (insects)	Whole body, hive, larva, adult.	Additional nutrition for nutritional deficiency.	Dagyom and Gopi (2009)
	Apatani, Nyishi, Monpa	100 (mammals, birds, reptiles, fish, mollusks, arthropods)	Whole animal, meat, bone, fat, skin, gall bladder, gut, shell, alimentary canal, penis, horn, blood, mucus, feathers and legs (birds).	Jaundice, indigestion, stomach ailments, asthma, tuberculosis, dysentery, boil, snake and scorpion bites, cough, headache, bronchitis, stroke, hallucination, wound, pox, anemia, weakness, skin disease, malaria, piles, rheumatic pain, typhoid, nasal congestion, night blindness, paralysis, impotency.	Solanki and Chutia (2009)
	Nyishi, Galo	81 (local insects)	Whole insect, larval stages, nymphs, adult stages, pupae, eggs.	Cough, fever, stomach ailments, skin irritation, scabies, toothache, high blood pressure, boil, wounds, malaria, dysentery, chest pain.	Chakravorty et al. (2011a)
	Nyishi, Galo	36 (vertebrates)	Mucus, stomach, gut, fins, bones, whole body, fats, flesh, feathers, testicles, frontal bone, skin, intestine, nails, blood, bone marrow.	Burns, stomach ache, digestive problems, body burns, diarrhea, smallpox, wound healing, joint pain, diseases in cattle, early pregnancy, tuberculosis, gastritis, jaundice.	Chakravorty et al. (2011b)
	Adi	39 (aquatic and terrestrial)	Bones, meat, skull, wings, eggs, tail, gall bladder, ant larvae.	Diabetes, weakness, fertility enhancement, malaria, skin disease, joint pain, taboos and spiritual purposes.	Chinlampianga et al. (2013)

	Wancho and Tangsa	Tangsa:55 Wancho: 20 (vertebrates and invertebrates)	Gall bladder, bile, body fat, flesh, liver, lactating breast, tooth, scales, blood, whole body, stomach, intestine, wings/appendages, brain, urinary bladder, excreta, bone marrow, limb bones, budding tender antlers (Sambar and Hog deer), urine, tail fat (Pied hornbill and domestic chicken), head and shell (tortoise), honey (bees), live leech, hemolymph.	Common day-to-day disorders, general weakness, body pain, fever, asthma, allergies, diarrhea, stomach ailments, cough, cold, dermal conditions, hemorrhoids, diabetes, burns, jaundice, liver problem, earache, malaria, epilepsy, tuberculosis, cancer, venomous snake bites.	Jugli et al. (2019)
Assam	Ethnic communities of Dibrugarh	4 (fishes)	Edible portion of fish, blood.	Body pain, carbuncle, diabetes, obesity.	Kalita et al. (2005)
	Karbi	14 (mammals, birds, insect, mollusk, reptiles, crustaceans)	Decayed flesh, saliva, whole body, elephant teeth, raw blood, meat, feather (Crane), legs (goat, deer), gall bladder, bile, fat.	Corn, eye disease, jaundice, itch, tuberculosis, joint pain, fever, infections, urinary problems, rheumatic pain, chest pain, stomach disorder, headache, haircare.	Hanse and Teron (2012)
	Karbi	14 (fishes)	Whole fish, raw blood, head, bile, belly, fats, brain, flesh, eyes.	Depression, anemia, kala-azar, constant spitting, weakness after delivery, night blindness, smallpox, wounds, dysentery, common cold, rheumatism, arthritis, stomach ache, corn, testicle swelling, malaria.	Teronpi et al. (2012)
	Biate	34	Gall bladder, flesh, fat, whole body, brain, scales, bone, skull bone, hand, front foot, urine, fur, blood, teeth, tongue.	Diabetes, snake bite, seizure, sprain, piles, burn, jaundice, impotency, allergy, rheumatic pain, tuberculosis, arthritis, gall stone, joint pain, malaria, dizziness, hernia, epilepsy, mumps, toothache, food poisoning, hair care, blood pressure.	Betlu (2013)
	Karbi	48 (mammals, insects, birds)	Insects: Honey, whole body, hind legs. Annelids: Live leech. Amphibians: Hind legs, skin, whole body, flesh Reptiles: Fat, whole body, blood, heart, eggs. Birds: Feathers, flesh, blood, fat, excreta. Mammals: Milk, urine, fat, dung, penis, bile, testicle, liver, droppings, blood.	Cough, flu, asthma, diuretic, baldness, lung infection, throat inflammation, anti-cancer, warts, rabies, arthritis, urinary tract problems, wounds, tongue blister, piles, joint pain, leprosy, stammering, paralysis, typhoid, toothache, blood pressure, breathing problem, nasal congestion, whooping cough, rheumatism, dysentery, tumors, bronchitis, anemia, eczema, malaria, jaundice, tuberculosis, asthma, cancer, skin disease, conjunctivitis.	Verma et al. (2014)
	Nath, Karbi	26 (mammals, fishes, birds, annelids, insects, reptiles)	Meat, urine, skin, alimentary canal, dung, oil, whole insect, honey, whole body, whole fish, blood.	Diarrhea, blood pressure, dysentery, bone fracture, asthma, jaundice, chickenpox, liver disease, tonsil, body ache, leucorrhea, skin disease, female infertility, joint pain, blood cancer, pneumonia, cough, burn, piles, skin disease, abdominal pain, polio, dysmenorrhoea, tuberculosis.	Borah and Prasad (2016)

	Ahom, Chutia, Koch-Rajbonshi, Kalita, tea tribes (Adivasis).	44 (insects, mammals, fishes, reptiles, annelids, amphibians, gastropods)	Whole body, soft watery portion, cocoon with larva (insects), head, heart with blood, meat, gall bladder, whole fish, milk, urine, horn, alimentary canal.	Asthma, otorrhoea, cancer, pain, sinus, epistapix, fever, eyesight, pneumonia, vocal cord infection, piles, impotency, bone fracture, gastric ulcer, wounds, anemia, blood pressure, pox, snake bite, skin disease, tonsil, rabies, chronic dysentery, paralysis.	Borah and Prasad (2017)
Manipur	Different ethnic groups of Manipur	33 (28 vertebrates, 5 invertebrates)	Invertebrates: Whole body, honey. Vertebrates: Whole fish, raw blood, bile, flesh, fat, brain, bone, leg, milk, urine, meat, intestine, fur.	Asthma, diabetes, tuberculosis, urine problems, antidote in snake bites, stomach disorders, eye problems, jaundice, liver disorders, body ache, wounds, anemia, common cold, smallpox, diarrhea, malaria, rheumatic pain, arthritis, skin disease, piles, hair care, and magico-religious purposes.	Devi et al. (2015)
	Meitei, Meitei Pangals, Chothe, Kabui, Kom	21 (fishes)	Whole body, liver, bile, eye, operculum, flesh, body oil, barbels.	Night blindness, chronic fever, piles, meningitis, constipation, deworming, ripening/swelling of boils, vitamins and general body tonic, anemia, malnutrition, post-delivery diet, lactation, tuberculosis, blood purifier, arthritis, cracked heels, night blindness, scurvy, food poisoning, brain improvement, kwashiorkor, dysentery, vaginal problems, ringworm, plague, ulcer.	Chanu et al. (2016)
	Rongmei	26 (mammals, birds, reptiles, amphibians, mollusks, insects)	Mammals: Bone, flesh, urine, bile, tongue, bone marrow, fat, stomach, hand/palm, penis, hair, whole body, leg, milk. Birds: Fat, whole bodies, bone, flesh. Reptile: Body and fat. Amphibian: Body. Mollusc: Whole body Insect: Whole body.	Tuberculosis, stomach disorder, stone case, alcoholic addict, wounds, injuries, sprains, cough, typhoid, boil, malaria, unconsciousness, epilepsy, burns, frequent urination, impotency, eye pain, bone joining, white discharge, skin diseases and cancer.	Ngaomei and Singh (2016)
Meghalaya	Khasi	13 (mammals, annelids, arthropods, fishes)	Whole body, fat/oil, bile, milk (tigress), fetus (pregnant deer), live fish, whole leech, insect intestine.	Malaria, burns, breastfeeding problems, tongue blemish of infants, boils, whooping cough, rash, wounds.	Mihsill and Keshan (2017)
Mizoram	Mizo	56 (25 vertebrates, 31 invertebrates)	Bones, ribs, hair, meat, blood, brain, bone marrow, bile, male organ, fatty oil, milk, scrotum, urine, tongue, tooth, stomach, intestine, toes, feathers, quill, fluids from neck.	Jaundice, convulsions, fractures, swellings, measles, liver ailments, tuberculosis, inflammatory glands, boils, chronic ulcers, asthma, chickenpox, bee sting, rheumatism, fever, headache, itch, pneumonia, piles, splenomegaly, diphtheria, whooping cough, weakness, otorrhoea, snake bite, night blindness, easy labor.	Lalramnghinglova (1999)
	Mizo	48	Fat, feathers, hair, bile, blood, urine, skull, fatty oil, meat, bone, skin, milk, liver, horn, tongue, intestine, rectum, male organ, brain, ribs.	Cough, asthma, tuberculosis, paralysis, earache, weakness, muscular pain, malarial fever, convulsion, diabetes, arthritis, leprosy, wounds, burns, diarrhea, respiratory ailments, kidney problems, cholera, hypertension, jaundice, liver problems, etc.	Chinlampianga et al. (2013)

	Mizo, Bru and Chakma	22 (mammals, reptiles, birds)	Gall bladder, bones, brain, blood, tooth, fat, nails, liver, stomach, intestine, meat, quill, scales.	Stomach ache, dysentery, diarrhea, cholera, malaria, epilepsy, vitamin, supplement, facilitate labor pain, strengthening of bones, stunted growth in infants, to protect body from evil soul, tooth decay, high blood pressure, asthma, epilepsy, convulsion, birth control, hair care, itching, kidney problem, diabetes, pneumonia, burns, cholera, cough.	Solanki et al. (2016)
Nagaland	Chakhesang	23 (mammals, reptiles, birds, amphibians, fishes, mollusk, annelids, arthropods)	Gall bladder, penis, hair, fat, urine, blood, spine (porcupine), small intestine, stomach, flesh, scale, bone marrow, feather, liver, skin, slimy mucus (fish), mollusk shell, honey from bees.	Wounds, thorns in flesh, gestation/child delivery, burn, swelling, stomach pain, anemia, bone fracture, gastritis, malarial fever, urethritis, constipation, cough, typhoid, tongue blisters, earache, dysentery, chickenpox.	Kakati and Doulo (2002)
	Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma	26 (mammals, birds, amphibians, reptiles, annelids, insects, crustaceans)	Whole body, flesh, fresh blood, fat, skin, gall bladder, bile duct, penis, urine, teeth and tusks (elephant), intestine, milk (goat), urine.	Antidote in snake and spider bites, asthma, stomach ache, tuberculosis, eye problems, jaundice, liver disorders, rheumatic joint pain, anemia, weakness, burns, wounds, fractures, earache, aphrodisiac, general weakness, night blindness, impotency, chest pain, fever, pile, facilitating delivery, leukoderma, eczema, ringworm, breast pain of lactating mothers, cholera, dysentery, cataract, food poisoning.	Jamir and Lal (2005)
	Ao	25 (vertebrates) (mammals, birds, reptiles, amphibians, fishes)	Fat, flesh, bile, tooth, intestine, bile, urine, liver, legs, milk, penis, blood, bones, skin.	Body pain, sprain, rheumatism, asthma, liver cirrhosis, leukoderma, itch, eczema, ringworm, anti-poison, tuberculosis, paralysis, skin disease, stomach disorder, jaundice, night blindness, fracture, weakness, breast pain of lactating mothers, impotency, burn, snakebite, malaria, dysentery, kidney stones, breathing problem, earache, stammering, piles, snake bites, wounds.	Kakati et al. (2006)
Sikkim	Lepcha, Bhutia and Nepali (including sub-communities)	59 (mammals, birds, insects, amphibians, reptiles, lower groups)	Mammals: Gall bladder, bones, meat, teeth, horn, skin, musk gland (Himalayan Musk Deer), scales, fur, urine, milk. Birds: Meat. Reptile: Molted skin (King Cobra). Amphibian: Meat, egg. Insects: Body, honey. Others: Spider web, crab and snail meat, whole worm	Fever, liver problems, heart disease, diabetes, wounds, body ache, dysentery, asthma, rheumatism, piles, gout, joint pain, tuberculosis, epilepsy, parturition, food poisoning, constipation, ear pain, cough, cold, urinary tract infection, immunity booster, pneumonia, bone fracture, snakebite, malaria, bedwetting, burns, eye pain, nose bleed, improvement of vision, ulcers.	Dhakal et al. (2019)
Tripura	Tripuri, Jamatia and Reang	25 (vertebrates and invertebrates)	Whole body, flesh, honey, head, casts of slough, testis, fecal matter, blood, antler, urine, meat, intestine, droppings.	Arthritis, conjunctivitis, weakness, rickets, asthma, cough, pneumonia, urinary obstruction, hair loss, sex stimulant, wound, leprosy, male impotency, constipation, paralysis, earache, joint pain, fever, TB, ulcer, gout, burn, fracture.	Das (2015)

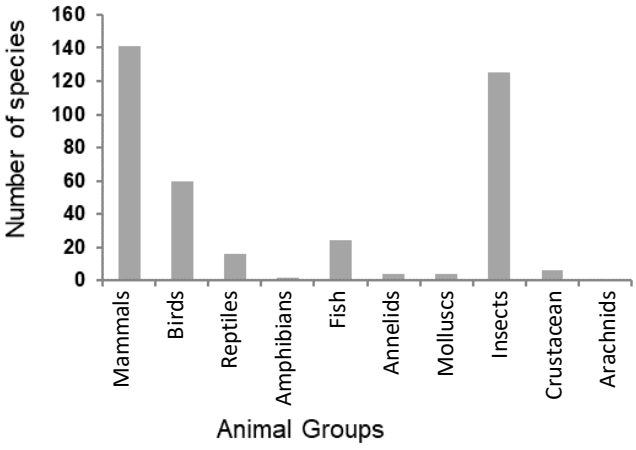

Figure 2. Type of animals used by different indigenous communities of Arunachal Pradesh, India

Arunachal Pradesh

Arunachal Pradesh is inhabited by 20 major indigenous communities (Dutta and Dutta 2005; Tynsong et al. 2020). These indigenous communities rely primarily on forest resources and follow activities such as collection of Non-Timber Forest Products (NTFPs), hunting, fishing, and animal trapping for their use in ethnomedicine and food (Solanki et al. 2004; Solanki and Chutia 2009).

Research by Solanki and Chutia (2009) stated that indigenous communities, namely Nyishi, Apatani, and Monpa, use approximately a total number of 100 animal species for their ethnomedicines; 48% of which belongs to mammalian species, 28% avian species and rest belong to amphibians and reptiles. For mammals, body parts such as skin, bones, fats, gall bladder, food pipe, reproductive organ and horns are used, whereas, in case of avian species, feathers and legs are predominantly used in traditional medicine formulations. Furthermore, the use of edible insects is also prevalent among the Galo community in ethnomedicine. Dagyom and Gopi (2009) reported a total of 12 edible insects along with four unidentified species that were used for ethno-zoological purposes by Galo tribes. A research carried out by Chakravorty et al. (2011a) reported that Nyishi and Galo communities use 81 species of edible and therapeutic insects and 36 vertebrate species for treating different ailments. Use of therapeutic insects and vertebrates by Nyishis and Galos has been found effective in curing ailments in domesticated cattle (Chakravorty et al. 2011b). Chinlampianga et al. (2013) estimate that Adi community use approximately 39 animal species (terrestrial and aquatic) in their conventional healthcare practice program. Bear, deer, ant's larvae, fish, porcupine tail, lizard, squirrel, hornbill, monkey, etc. are some of the species used by the Adi community. Usage of fish species viz., *Heteropneustes fossilis* and *Clarius batracus* and the use of insects with ant's larvae by females of Adi community have been reported to cure weak people and malaria sufferers (Chinlampianga et al. 2013). Monpa community uses about 11 animals (mammals and birds) for therapeutics as well as in many rituals of healing and religion (Solanki and Chutia 2004). The children of the Monpas are made to wear bear claws around their necks in their ancestral rituals as a belief in protecting them from evil spirits and performing the sacrifice of animals such as sheep, goats, etc., with a belief that satisfying their gods will alleviate suffering and promote healing (Solanki and Chutia 2004). Recent research by Jugli et al. (2019) recorded the use of 20 and 55 animal species among the ethnic groups of Wancho and Tangsa respectively, for therapeutics in humans and domesticated animals.

Figure 2 provides a graphic representation of the applications of animal classes by various indigenous communities of Arunachal Pradesh. The application of mammals, insects and birds is found to be the highest, while the application of other classes such as reptiles, amphibians, annelids, mollusks and crustaceans is seen to be less.

Assam

Assam is the second largest state in NE India and is home to a large number of cultural, natural as well as biological diversities (Borah and Prasad 2016). There have been numerous studies on the use of traditional plant-based medicine (Sajem and Gossai 2006; Saikia et al. 2006; Das et al. 2008; Sikdar and Dutta 2008), and mixed formulations using both plants and animals (Kalita et al. 2005; Betlu 2013) reported from the state. There are, however, very few reports on the use of animal-based medicines for treatment of ailments. Some studies relating to use of animals in traditional medicines are of Borah and Prasad (2016) on the application of 26 animal species to treat diseases like jaundice, asthma and pneumonia by local ethnic groups viz., Nath and Karbi; Borah and Prasad (2017) on extensive use of 44 species of animals for several ethno-zoological applications by indigenous communities like Ahom, Chutia, Koch-Rajbonshi, Kalita, and Tea tribes (Adivasis). Similarly, Hanse and Teron (2012), Teronpi et al. (2012), and Verma et al. (2014) also conducted a study among the Karbi community of the Karbi-Anglong District of Assam on the applicability of 14 species of animals, 14 species of ichthyofauna (fish), and 48 species of various animals respectively, for therapeutic purposes in the treatment of diseases such as piles, cancer, tuberculosis and eczema.

Analysis of reports from the state of Assam reveals that use of mammals is the highest, followed by fish, insects, birds, and reptiles (Figure 3). Application of other groups of animals like amphibians, annelids, mollusks, crustaceans and arachnids are least in use.

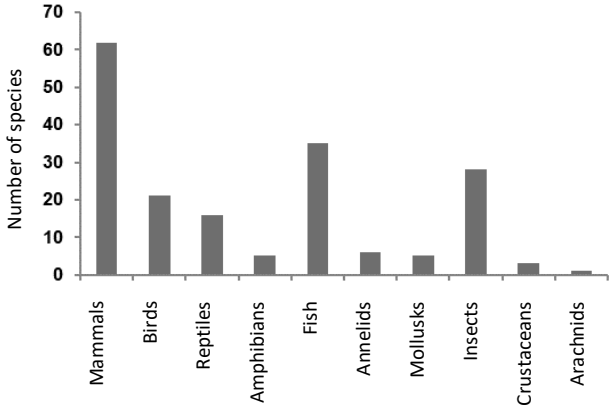

Figure 3. Type of animals used by different indigenous communities of Assam

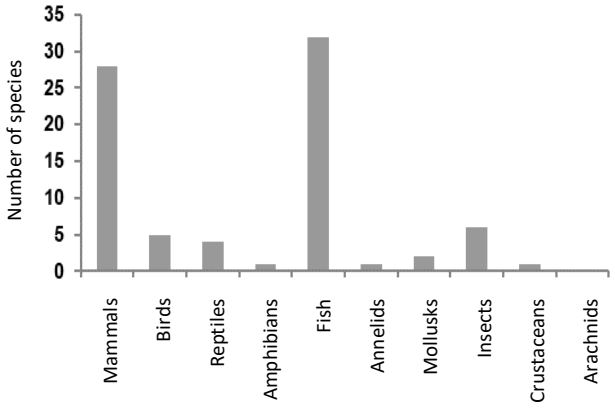

Figure 4. Type of animals used by different indigenous communities of Manipur

Manipur

Manipur is an oval-shaped valley state surrounded by hills (Devi et al. 2015). The State is known for its rich and varied natural resources, and is home to many native flora and fauna species (Chanu et al. 2016). Zootherapy among several groups in Manipur has been found to be an integral part of traditional folk healthcare practices (Devi et al. 2015). Indigenous communities of Manipur are accustomed to using a large number of animal species (wild and domesticated) in zoo-therapy procedures, the activities that involve both local and oral methods (Devi et al. 2015).

Research conducted by Chanu et al. (2016) recorded that the Meitei community had used some fish species as ethnomedicine. A total of 21 species of fish belonging to 11 families and 18 genera have been primarily used in the preparation of ethnomedicine by the Meitei community (Chanu et al. 2016). Fish are eaten raw, fried, or cooked for medicinal purposes, depending on the procedure prescribed/followed. Some of the most common fish species used by the Meitei community in ethnomedicine include *Aorichthys seenghala*, *Anguilla bengalensis*, *Barilius bendelisis*, *Catla catla*, *Channa orientalis*, *Channa striatus*, *Esomus danrica* and *Hilsha ilisha*. Meitei Folk Healers use liver, eye, bile, operculum, fish oil, barbels, and sometimes whole body of the fish (Chanu et al. 2016).

Another important study on animal-based ethnomedicine in Manipur had reported that a total of 33 animals are used in traditional zoo-therapy treatments by the traditional folk healers of Manipur; comprising of five invertebrates and 28 vertebrate species for treatment of 35 different ailments (Devi et al. 2015). It is stated that there are four different types of traditional zoo-therapies employed by Manipur's traditional folk healers, i.e., food, medicine, magico-religious, and faith healing, in which animals are either used completely or in parts depending on their needs. Similarly, Ngaomei and Singh (2016) reported that the Rongmei community of Manipur used a total of 26 animal species consisting of 14 mammals, 3 avian species, 3 reptiles, 2 amphibians, 1 mollusk, and 4 insect species to treat ailments such as rheumatic pain, typhoid and stomach disorders. The Rongmei community usually uses parts of the body such as flesh, bones, bone marrow, urine, bile, tongue, fat, stomach, hand, palms, hair, and whole body in traditional medicine formulations.

It is observed that application of fish species in traditional medicines is highly prevalent in Manipur, followed by the use of mammals, insects, birds and reptiles (Figure 4). Use of amphibians, annelids, mollusks, and crustaceans is also prevalent.

Meghalaya

In Meghalaya, indigenous communities have existed in profound and intense communion with nature from time immemorial (Mihsill and Keshan 2017). The Khasi, Jaintia, and Garo are the three primary indigenous communities in Meghalaya, which together constitute 86% of the overall population of the state (Tiwari et al. 2010). There have been numerous studies on the use of traditional plant-based medicine (Laloo et al. 2006; Tynsong et al. 2006; Sawian et al. 2007; Hynniewta and Kumar 2008) while reports on the use of traditional medicine based on animals in Meghalaya are extremely limited. Research conducted by Turnia and Prasad (2017) confirmed that the Khasi community used 13 animal-based medicine to treat ailments such as asthma, anemia, diarrhea and regular cough, cold and fever. Mihsill and Keshan (2017) documented the use of animals and animal products in traditional cure practices by the Khasis. Mihsill and Keshan (2017) reported that Khasi community believe that malaria can be cured by consuming hill mole (known as 'kyndat lyndang' in Khasi dialect) or cow bile, tigress milk mixed with mud in healing burns; sun-dried deer fetus to cure 'suhsynria' in khasi dialect (a condition of disease prevalent in breastfeeding mothers), use of catfish (*Channa striatus*) to treat a condition similar to leukoderma in infants and use of leeches to suck blood from pus boils.

It is observed that in Meghalaya, mammals are mainly used in traditional medicine followed by insects. However, use of other animal groups like birds, amphibians, mollusks, crustaceans, etc., for zoo-therapeutic applications is not reported (Figure 5).

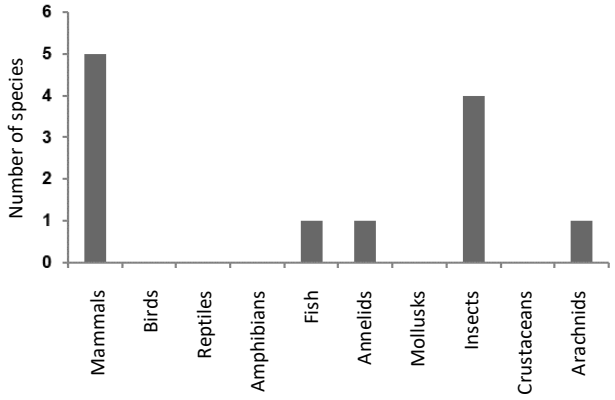

Figure 5. Type of animals used by different indigenous communities of Meghalaya

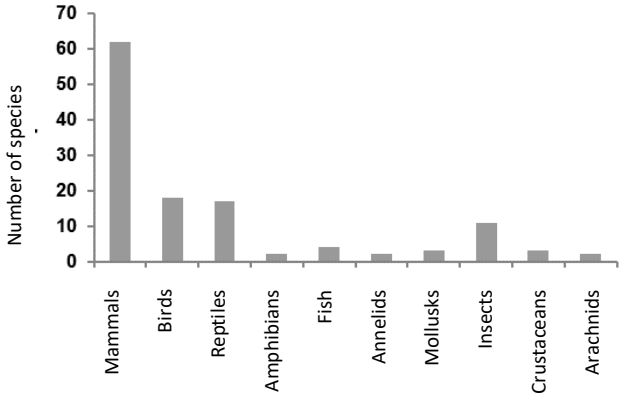

Figure 6. Type of animals used by different indigenous communities of Mizoram

Mizoram

Mizoram is a hilly state located in the lower corner of the NE region, traversing many ranges of hill slopes; and less scattered plains and is inhabited primarily by two distinct indigenous communities i.e., Chakma and Mara; besides other communities such as Lai, Paite, and Hmar (Chinlampianga et al. 2013). Traditional health care systems using animals were well defined and documented in Mizoram (Harit 2001). Mizoram's ground-breaking research on ethno-zoological traditional medicine emphasized the use of at least ten animal species for the treatment of asthma and respiratory disorders, including reports for multiple ailments of a total of 56 animal species (Lalramnghinglova 1999). A study conducted by Chinlampianga et al. (2013) in the Zomi-Paite community revealed that a total of 48 species of fauna consisting of mammals, birds, reptiles, arthropods, amphibians, annelids, insects, and fish are used for diseases like asthma, arthritis, leprosy, malaria, wound, respiratory, kidney, gynecological, cholera, tuberculosis, diabetes, hypertension, and jaundice. Animal body parts or organs used for the practice of ethnomedicine include fat, feather, hair, bile, blood, meat, bone, skin, milk, and liver; either in cooked/boiled/roasted form (Chinlampianga et al. 2013). Solanki et al. (2016) stated that the Mizo, Bru, and Chakma communities used animals for medicinal applications and approximately nine mammalian species, three reptiles, and one bird species have been commonly used for medicinal purposes, mainly utilizing body parts such as gall bladder, bones, brain, blood, hair, skin, nails, liver, stomach, and intestines.

Existing literature on zoo-therapeutic applications in Mizoram shows that use of mammals had been the largest, followed by use of birds, reptiles and insects. Applications of other animal groups such as amphibians, reptiles, annelids, mollusks, crustaceans, and arachnids are also prevalent but at comparatively smaller frequencies (Figure 6).

Nagaland

Nagaland state borders Arunachal Pradesh, Assam, and Manipur; and is made up of plains and hilly regions. Nagaland is inhabited by several indigenous communities like Ao, Angami, Lotha, Phom, Chang, Sangtam, Chakhesang, Zeliang, Rengma, Yumchunger, Khiamniungan, Konyak, Sema, Pochury and various sub-groups (Zhimomi 2004). Research conducted by Jamir and Lal (2005) on ethnozoological knowledge reported a total of 26 animal species used by 11 indigenous communities in Nagaland for zoo-therapeutic remedies. Cat, deer, bear, dog, elephant, goat, flying squirrel, jackal, monkey, frog, python, cobra, crow, pheasant, pigeon, peacock, earthworm, apple snail, cockroach, crab, scorpion and eel are some of the animals used for traditional medicine. Organ/body parts used for medical practice include whole meat, gall bladder; extracts from the bile ducts, fresh blood, and whole body consumed raw/cooked, skin and male organ.

Kakati and Doulo (2002) recorded animal use in traditional medicines among the Chakhesang community of Nagaland, which employed 23 animal species. Among the Ao community, comprehensive research on ethnozoological knowledge was conducted by Kakati et al. (2006), who recorded that people relied on zoo-therapeutic medicines to treat diseases such as body pain, rheumatism, asthma, liver disorders, tuberculosis, night blindness, bone fractures, malaria, dysentery, kidney problems, and respiratory disease. Kakati et al. (2006) recorded that a total of 25 different species of vertebrates are used by Ao community which include mammals, aves, reptiles, amphibians, and fish. Traditional healers of Ao community use body parts like fats, meat, bile, teeth, intestine, urine, liver, legs, milk, blood, bones, and skin.

It is noted that indigenous communities of Nagaland primarily use mammals in their traditional medicine accompanied in their various formulations, followed by birds, reptiles, amphibians and insects. Other animal groups such as fish, annelids, mollusks, crustaceans, and arachnids also find their uses in traditional medicine of Nagaland (Figure 7).

Sikkim

Sikkim is located in the foothills of the Himalayas, inhabited by indigenous communities like Lepcha, Bhutia and Nepali following diverse cultures and traditions (Dhakal et al. 2019). Literature survey on the use of

traditional medicine in Sikkim revealed that the state relies heavily on the state's flora, which has a rich and large range of natural resources (Dhakal et al. 2019). Knowledge regarding the use of faunal medicine as part of traditional folklore is fairly scanty and fragmentary. Dhakal et al. (2019) conducted a comprehensive survey of traditional communities and reported that males of such communities were dominant in traditional medicine usage compared to females; and are mostly people with lower annual incomes and practice as a part-time livelihood. Dhakal et al. (2019) recorded that 59 animal species were used in ethno-zoological practices, 71% of which were used in zootherapy, while the remaining 39% were recorded to be used in various religious or shamanic activities. Of the 59 animals, 34 were mammals, 13 bird species, and rest consisted of insects, amphibians, reptiles, mollusks, etc.; suggesting mammals as the dominant group used in traditional medicine (Figure 8).

Tripura

Tripura is a small hilly state, inhabited by 19 indigenous communities (Das 2015). Studies on traditional medicine using flora and fauna are extremely limited in Tripura, with few recorded studies on the use of ethnomedicinal plants (Das et al. 2009; Sen et al. 2011; Sharma et al. 2014; Debbarma et al. 2017), and scarce details on the use of ethnomedicine based on animals. A study on use of ethnomedicine based on animals by Das (2015) provided a detailed report on the applications of ethnozoological medicine practiced by the Tripuri, Jamatia, and Reang communities of Tripura. Das (2015) recorded the use of 25 animal species being used for the treatment of asthma, paralysis, cough, fever and wound healing. Many animals used in ethnomedicine include goat (for tuberculosis, ulcer and gout treatment), apple snail (conjunctivitis and rickets), pigs (fractures, burns and wounds), while animals such as cows and fish have been documented to be in lesser uses as compared to other animals (Das 2015). Existing literature on zoo-therapeutic applications in Tripura reveals that use of mammals is the highest, followed by use of insects, birds, crustaceans, and fish (Figure 9).

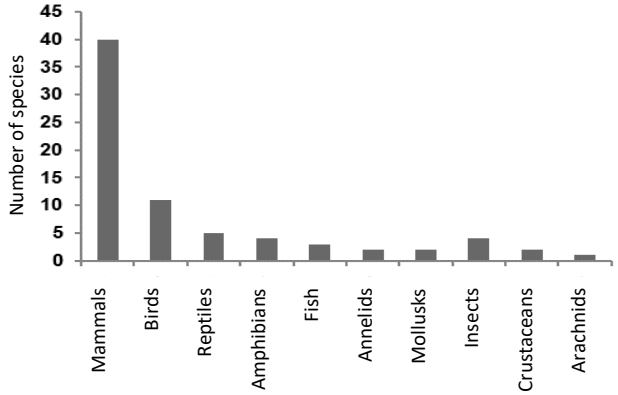

Figure 7. Type of animals used by different indigenous communities of Nagaland

Animals used in the treatment of various diseases

Based on our comprehensive literature survey, we could assess that malaria, tuberculosis, wounds, cough and cold, burns, dysentery, jaundice, stomach disorders, rheumatism, asthma, liver problems, joint pain, fever, fatigue, women's issues, fractures, animal/insect bites, anemia, male impotence and diabetes are the 20 most common diseases which are reported to be cured with the application of ethno-zoological medicines. Details of the types of animals used to treat these diseases and the indigenous communities involved are provided in Table 3.

In the ethnozoological applications among communities of NE India, mammals, fish, reptiles, annelids, amphibians, mollusks, insects, birds, crustaceans, mollusks, arachnids, etc., are widely used species types. Analysis of the IUCN Red List of Endangered Species (IUCN 2020) shows that 58 species are classified as Least Concern (LC), 21 species are classified as Vulnerable (VU), 9 species are classified as Endangered (EN), 7 species are classified as Near Threatened (NT), 3 species are classified as Critically Endangered (CR), 1 species is classified as Data Deficient (DD). Conservation status of these animal species as per IUCN (2020) is provided in Table 4.

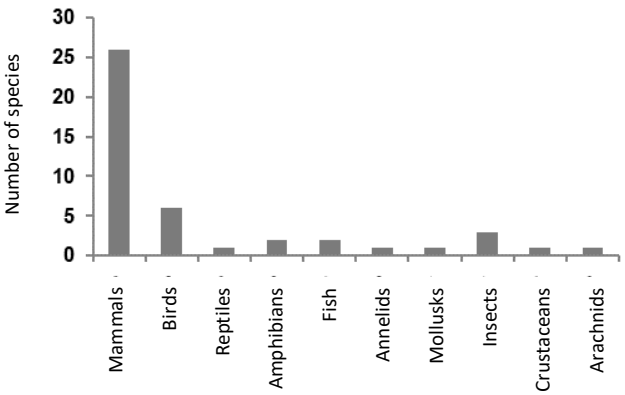

Figure 8. Type of animals used by different indigenous communities of Sikkim

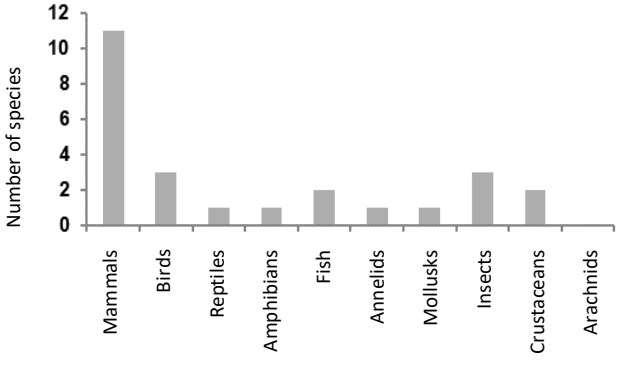

Figure 9. Type of animals used by different indigenous communities of Tripura

Table 3. Details and number of animals used in the ethno-zoological treatment 20 most common ailments/diseases

Disease	Animals used	Indigenous communities and their state	Literature
Malaria (37 species)	*Channa punctatus* (Snake head fish), *Anabus testudineus* (Fish), *Solenopsis* sp. (Red ant), *Aspongopus najus* (Tari insect), *Cimex lactularis* (Bed bug), *Hystrix indica* (Indian porcupine), *Maccaca assamensis* (Assamese Macaque), *Pheritima* sp. (Earthworm), *Tehanochelys trijuga* (Turtle), *Varanus bengalensis* (Monitor Lizard), *Viper ruselli* (Viper), *Haliaeetus* sp. (Eagle), *Dicrurus* sp. (Drongo), *Buceros bicornis* (Great Hornbill), *Megalaima* sp. (Barbet), *Panthera tigris* (Tiger), *Manis* sp. (Pangolin), *Pteropus* sp. (Flying fox), *Chiroptera* sp. (Bat), *Bothroponera rufipes* (Black ant), *Moschus* sp. (Musk Deer), *Ursus thibetanus* (Black bear), *Panthera pardus* (Leopard), *Trachypithecus pileatus* (Capped langur), *Macaca mulatta* (Rhesus monkey), *Bunopithecus hoollock* (Hoolock gibbon), *Corvus culminatus* (Jungle Crow), *Bos* sp. (Mithun), *Vulpes bengalensis* (Fox), *Testudo* sp. (Tortoise), *Mastacembelus armatus* (Spiny eel), *Canis aureus* (Golden jackal), *Nycticebus coucang* (Slow loris), *Talpa* sp. (Hill mole), *Python molurus* (Python), *Cancer pararus* (Crab) and *Felis silvestris* (Wild cat).	Adi, Apatani, Galo, Monpa, Nyishi, Tangsa and Wancho of Arunachal Pradesh; Biate and Karbi of Assam; Rongmei and other groups of Manipur; Khasis of Meghalaya; Mizo, Bru and Chakma of Mizoram; Ao and Chakhesang of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Solanki and Chutia (2004); Kakati et al. (2006); Chakravorty et al. (2011 a); Chinlampianga et al. (2013); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Ngaomei and Singh (2016); Solanki et al. (2016); Mihsill and Keshan (2017); Dhakal et al. (2019); Jugli et al. (2019).
Tuberculosis (21 species)	*Pila globusa* (Apple Snail), *Periplaneta americana* (Cockroach), *Moschus moschiferus* (Musk deer), *Talpa* sp. (Mole), *Vulpes bengalensis* (Fox), *Hystrix* sp. (Porcupine), *Selenarctos thibetanus* (Himalayan black bear), *Macaca assamensis* (Assamese macaque), *Hoolock leuconedys* (Eastern Hoolock Gibbon), *Python molurus* (Indian python), *Amphipnous cuchia* (Cuchia), *Capra hircus* (Goat), *Manis crassicaudata* (Indian pangolin), *Channa punctatus* (Spotted snakehead fish), *Tachypodoiulus niger* (Black millipede), *Canis familiaris* (Dog), *Macaca mulatta* (Rhesus monkey), *Naurey musa* (Mongoose), *Scylla* sp. (Mud crabs), *Eutropiichthys vacha* (Fish) and *Canis aureus* (Wild fox).	Apatani, Nyishi, Monpa, Galo and Tangsa of Arunachal Pradesh; Karbi, Biate and Nath of Assam; Meitei, Pangals, Chothe, Kabui, Kom (Moirang-maninghao), Rongmei and others of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Chakravorty et al. (2011b); Hanse and Teron (2012); Betlu (2013); Verma et al. (2014); Das (2015); Devi et al. (2015); Borah and Prasad (2016); Chanu et al. (2016); Ngaomei and Singh (2016); Dhakal et al. (2019); Jugli et al. (2019).

Wounds (33 species)	*Mastacembelus armatus* (Eel fish), *Chaca chaca* (Fish), *Python molurus* (Python), *Naja naja* (Cobra), *Spizaetus* sp. (Eagle), *Dicrurus* sp. (Drongo), *Strigiformes* sp. (Owl), *Buceros* sp. (Hornbill), *Megalaima* sp. (Barbet), *Panthera tigris*, *Bos frontalis*, *Hystrix brachyuran* (Porcupine), *Ursus thibetanus* (Himalayan Black Bear), *Manis* sp. (Pangolin), *Pteropus* sp. (Flying fox), *Chiroptera* sp. (Bat), *Bothroponera rufipes*, *Amblyceps* sp. (Fish), *Rana* sp. (Frog), *Panthera pardus*, *Mantis religiosa* (Praying mantis), *Clarias batrachus* (Magur fish), *Heteropneustes fossilis* (Singing catfish), Human urine, *Caurausius* sp. (Stick insect), *Araneae* sp. (Spiders), *Canis aureus* (Jackal), *Sus scrofa* (Pig), *Lepus nigricollis* (Indian Hare), *Tetragonula iridipennis* (Stingless bee), *Rucervus unicolor* (Sambar Deer), *Rhizomys sumatrensi* (Bamboo rat) and *Pila* sp. (Snail).	Apatani, Nyishi, Monpa, and Galo of Arunachal Pradesh; Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis and Karbis of Assam; Rongmei and other groups of Manipur; Khasi of Meghalaya; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Kakati and Doulo (2002); Kakati et al. (2006); Solanki and Chutia (2009); Chakravorty et al. (2011a); Teronpi et al. (2012); Verma et al. (2014); Das (2015); Ngaomei and Singh (2016); Borah and Prasad (2017); Mihsill and Keshan (2017); Dhakal et al. (2019).
Cough and cold (31 species)	*Apis* sp. (Honey bee), *Polistes* sp. (Wasp), *Vespa orientalis* (Potter wasp), *Melursus ursinus* (*Sloth* bear), *Moschus* sp., *Ursus thibetanus* (Asiatic Black Bear), *Anthracoceros albirostris* (Pied hornbill), *Python molurus*, *Cynopterus sphinx* (Bat), *Macrocheraia* sp. (Giant red bug), *Puntius sp*. (Fish), *Equus asinus* (Donkey), *Sciurus caroliniensis* (Squirrel), *Mus musculus* (House mouse), *Periplaneta americana*, *Calotes versicolor* (Common garn lizard), *Canis aureus*, *Helarctos malayanus* (Malayan sun bear), *Buceros* sp. (Great hornbill), *Corvus* sp. (Jungle crow), *Hystrix* sp., *Lepus nigricollis*, *Bos* sp. (Cattle), *Sus domesticus* (Pig), *Nanorana liebigii* (Frog), *Tetragonula iridipennis*, *Capra aegagrus* (Goat), *Felis silvestris*, *Macaca* sp. (Monkey), *Cancer pararus* (Crab), and *Podisus* sp. (Plant bug).	Nyishi, Galo, Apatani, Monpa, Tangsa and Wancho of Arunachal Pradesh; Nath and Karbi of Assam; Rongmei and other groups of Manipur; Khasi of Meghalaya; Mizo, Bru and Chakma of Mizoram; Chakhesang of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Lalramnghinglova (1999); Kakati and Doulo (2002); Solanki et al. (2004); Teronpi et al. (2012); Verma et al. (2014); Das (2015); Devi et al. (2015); Borah and Prasad (2016); Ngaomei and Singh (2016); Mihsill and Keshan (2017); Jugli et al. (2019); Dhakal et al. (2019).
Burns (30 species)	*Anguilla* sp. (Eel), *Bagarius* sp. (Gangetic goonch), *Amblyceps* sp. (Catfish), *Spilornis cheela* (Eagle), *Ursus thibetanus*, *Melursus ursinus*, *Panthera tigris*, *Neofelis nebulosa* (Clouded leopard), *Pteromys* sp. (Flying Squirrel), *Capra* sp., *Nycticebus* sp. (Slow loris), Human urine, *Buceros* sp., *Gallus domesticus* (Chicken), *M. armatus* (Spiny eel fish), *Python reticulates* (Reticulated python), *Sartoriana* sp. (Red freshwater crab), *Varanus bengalensis*, *Gallus* sp. (Jungle Fowl), *Lutrogale perspicillata* (Smooth-coated otter), *Metaphire houletti* (Earthworm), *Apis* sp. *Canis* sp. (Dog), *Manis* sp., *Sus scrofa* (Pig), *Ovis aries* (Sheep), *Lymnonecties* sp. (Frog), *Cervus* sp. (Deer), *Hystrix* sp., and *Pila* sp. (Snail).	Nyishi, Galo, Tangsa and Wancho of Arunachal Pradesh; Biate, Nath and Karbi of Assam; Rongmei, of Manipur; Khasi of Meghalaya; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Kakati and Doulo (2002); Jamir and Lal (2005); Kakati et al. (2006); Chakravorty et al. (2011b); Betlu (2013); Das (2015); Borah and Prasad (2016); Ngaomei and Singh (2016); Solanki et al. (2016); Mihsill and Keshan (2017); Dhakal et al. (2019); Jugli et al. (2019).

Dysentery (32 species)	*Acheta* sp. (Cricket), *Dinocras cephalotes* (Stone fly), *Ephemera dancia* (May fly), *Philopotamus montanus* (Caddis fly), *Musca domestica* (Housefly), *Gallus gallus*, *Dicrurus* sp. (Drongo), *Tyto alba* (Brown owl), *Buceros* sp. (Hornbill), *Megalaima* sp. (Barbet), *Panthera tigris*, *Moschus moschiferus* (Musk deer), *Macaca assamensis*, *Trachypithichus pileatus* (Capped langur), *Bunopithicus hoolock* (Hoolock gibbon), *Ursus thibetanus* (Himalayan Black Bear), *Manis* sp. (Pangolin), *Pteropus giganteus* (Flying fox), *Cynopterus sphinx* (Bat), *Bothroponera rufipes* (Black ant), *Oecophylla smaragdina* (Red tree ant), *Hystrix* sp., *Panthera pardus*, *Python* sp., *Cervus* sp. (Musk Deer), *Bos indicus* (Cow), *Channa gachua* (Fish), *Varanus bengalensis*, *Pseudois nayaur* (Himalayan blue sheep), *Hemitragus jemlahicus* (Himalayan Tahr), *Mystus bleekeri* (Fish), and *Nanorana liebigii* (Frog).	Apatani, Nyishi, Galo and Monpa of Arunachal Pradesh; Ahom, Chutia, Koch-Rajbonshi, Kalita, Adivasis, Nath, Karbi and Dimasa of Assam; Meitei, Meitei Pangals, Chothe (Lamlanghupi), Kabui (Nambol), Kom (Moirang-maninghao) of Manipur; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim;	Kakati and Doulo (2002); Jamir and Lal (2005); Kakati et al. (2006); Chakravorty et al. (2011a); Chakravorty et al. (2011b); Teronpi et al. (2012); Verma et al. (2014); Borah and Prasad (2016); Chanu et al. (2016); Solanki et al. (2017); Dhakal et al. (2019).
Jaundice (24 species)	*Capricornis sumtraensis* (Serow), *Naemorhedus goral* (Himalayan Goral), *Pseudois nayaur* (Bharal), *Budorcas taxicolor* (Takin), *Macaca assamensis Trachypithichus pileatus*, *Bunopithicus hoolock*, *Ursus thibetanus*, *Manis pentadactyla*, *Pteropus giganteus* (Flying fox), *Cynopterus sphinx* (Bat), *Panthera tigris*, *Melursus ursinus*, *Hystrix* sp., *Varanus bengalensis*, *Rhinoceros unicornis* (one-horned Rhino), *Bos indicus* (Cow), *Amphipnous cuchia* (Eel), *Ovis aries* (Sheep), *Corvus macrorhynchos* (Jungle crow), *Lymnaea* sp. (Water snail), *Xestina* sp. (Land snail), *Capra* sp., and *Cancer pararus* (Crab).	Apatani, Nyishi, Galo, Monpa and Tangsa of Arunachal Pradesh; Nath, Karbi and Biate of Assam; Mizo of Mizoram; Ethnic groups of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Hanse and Teron (2012); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Jugli et al. (2019).
Stomach ailments (29 species)	*Pila* sp., *Cancer pararus*, *Polistes herbraeus* (Wasp), *Dinocras cephalotes* (Stone fly), *Ephemera dancia* (May fly), *Philopotamus montanus* (Caddis fly), *Varanus bengalensis*, *Geoemyda mouhati* (Tortoise), *Ursus thibetanus*, *Manis* sp., *Apis* sp., *Oecophylla smaragdina* (Red tree ant), *Semiplotus* sp., (Fish), *Labeo rohita*, *Bagarius* sp., *Corvus splendens*, *Capra* sp., *Moschus* sp., *Melursus ursinus*, *Python molursus*, *Geochelone emys* (Eastern hill tortoise), *Hoolock hoolock*, *Macaca* sp., *Antilocapra americana* (Antelope), *Hystrix* sp., *Callosciurus* (Oriental tree squirrel), *Archispirostreptus gigas* (Millipede), Human urine and *Sus crisatus* (Wild boar).	Apatani, Nyishi, Galo, Monpa, Tangsa and Wancho of Arunachal Pradesh; Karbi and Dimasa of Assam; Rongmei of Manipur; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Hanse and Teron (2012); Teronpi et al. (2012); Devi et al. (2015); Ngaomei and Singh, (2016); Solanki et al. (2016); Jugli et al. (2019).

Rheumatism (33 species)	*Varanus bengalensis*, *Naja naja* (Cobra), *Haliaeetus* sp. (Eagle), *Megalaima* sp. (Barbet), *Pardofelis* sp. (Marbled cat), *Civettictis* sp. (Civet), *Martes flavigula* (Yellow-throated marten), *Mustela* sp. (Weasel), *Herpestes* sp. (Mongoose), *Lutrinae* sp. (Otter), *Moschus moschiferus*, *Hystrix brachyuran*, *Panthera tigris*, *Panthera paradus*, *Cervulus muntjac* (Barking deer), *Cryptozona* sp. (Snail), *Hoolock hoolock*, *Puntius* sp. (Fish), *Crotalus durissus* (Neotropical rattle snake), *Dusicyon* sp. (Fox), *Ovis aries*, *Arctonyx collaris* (Hog badger), *Buceros* sp. (Wheated hornbill), *Bagarius* sp., *Sus scrofa*, *Anguilla bengalensis*, *Salenarctos* sp., *Palamnaeus swammerdami* (Scorpion), *Python reticulates*, *Lymnonecties limnorcharis* (Frog), *Centropus sinensis* (Greater Coucal), *Bubalus arnee* (Wild water Buffalo), and *Corvus splendens*.	Apatani, Nyishi, Monpa of Arunachal Pradesh; Karbi and Biate of Assam; Ethnic groups of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Hanse and Teron (2012); Teronpi et al. (2012); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Dhakal et al. (2019).
Asthma (37 species)	*Pila* sp., *Periplaneta americana*, *Acheta* sp., *Mastacembelus armatus*, *Monopterus cuchia* (Eel fish), *Varanus bengalensis*, *Geoemyda mouhati* (Tortoise), *Capricornis sumtraensis* (Serow), *Naemorhedus goral* (Goral), *Pseudois nayaur*, *Budorcas taxicolor*, *Hoolock leuconedys*, *Anthracoceros albirostris* (Pied hornbill), *Cynopterus* sp. (Bat), *Polypedates leucomystax* (Common tree frog), *Amblypharyngodon mola* (Indian carplet fish), *Chaca chaca*, *Herpestes edwardsii*, *Sciurus caroliniensis* (Squirrel), *Apis* sp., *Pseudacanthotermes* sp. (Termite), *Talpa* sp., *Bos gaurus* (Indian Bison), *Calotes versicolor*, *Canis familiaris*, *Centropus sinensis*, *Hystrix indica*, *Picus canus* (Black napped green woodpecker), *Viverricula indica* (Small Indian Civet), *Carcinus* sp., *Pteropus* sp. (Flying fox), *Ursus thibetanus*, *Lumbricus* sp. (Earthworm), *Capra* sp., *Petaurista petaurista* (Red Giant Flying squirrel), *Gallus sonnerati* (Jungle fowl), and *Columba livia* (Pigeon).	Apatani, Nyishi, Monpa, Tangsa and Wancho of Arunachal Pradesh; Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis, Nath and Karbi of Assam; Ethnic groups of Manipur; Mizo, Bru and Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim; Tripuri, Jamatia and Reang of Tripura.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Verma et al. (2014); Das (2015); Devi et al. (2015); Borah and Prasad (2017); Dhakal et al. (2019); Jugli et al. (2019).
Liver ailments (14 species)	*Vulpes bengalensis* (Fox), *Rhizomys pruinosus* (Hoary bamboo rat), *Hystrix* sp., *Cynopterus sphinx* (Bat), *Hoolock leuconedys* (Hoolock gibbon), *Bos indicus* (Cow), *Wallago attu* (Fish), *Cancer* sp. (Crab), *Lymnaea* sp. (Water snail), *Melursus ursinus* (Sloth bear), *Rhinoceros unicornis* (One-horned Rhino), *Ursus thibetanus*, *Capra* sp., and *Felis* sp. (Wild cat).	Nyishi, Tangsa of AP; Nath and Karbi of Assam; Ethnic groups of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Solanki et al. (2004); Jamir and Lal (2005); Kakati et al. (2006); Hanse and Teron (2012); Teronpi et al. (2012); Devi et al. (2015); Borah and Prasad (2016); Dhakal et al. (2019); Jugli et al. (2019).

Joint pain (13 species)	*Bagarius* sp., *Python molurus*, *Ursus thibetanus* (Asiatic Black Bear), *Pteropus medius* (Flying fox), *Canis aureus*, *Capricornis sumatraensis* (Mainland serow), *Sus scrofa domesticus* (Pig), *Xenentodon cancila* (Freshwater gar fish), *Echis coloratus* (Viper), *Struthio camelus* (Common Ostrich), *Macaca mullata* (Rhesus macaque), *Buceros bicornis* (Hornbill), and *Apis dorsata* (Giant bee).	Nyishi, Galo, and Tangsa of Arunachal Pradesh; Karbi, Biate, Nath of Assam; Mizo of Mizoram; Tripuri, Jamatia and Reang of Tripura; Lepcha, Bhutia and Nepali of Sikkim; Rongmei Manipur.	Hanse and Teron (2012); Betlu (2013); Verma et al. (2014); Das (2015); Borah and Prasad (2016); Ngaomei and Singh (2016); Dhakal et al. (2019); Jugli et al. (2019).
Fever (21 species)	*Apis* sp., *Oecophylla smaragdina*, *Selenarctos thibetanus*, *Bunopithecus hoollock*, *Cynopterus sphinx* (Bat), *Maydelliathelphusa lugubris* (Fresh water crab), *Canis familiaris* (Dog), *Vulpes* sp., *Leptocorisa varicornis* (Rice bug insect), *Hystrix indica*, *Cyprinus carpio* (Common carp), *Bos indicus* (Cow), *Manis pentadactyla* (Chinese pangolin), *Bandicota* sp. (Mole), *Herpestes* sp. (Mongoose), *Corvus macrorhynchos* (Large billed crow), *Aorichthys seenghala* (Fish), *Mastacembelus armatus*, *Cervus* sp. (Deer), *Trachypithecus pileatus*, and *Macaca assamensis*.	Nyishi, Galo, Monpa and Tangsa of AP; Karbi, Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis of Assam; Mizo of Mizoram; Tripuri, Jamatia and Reang of Tripura; Lepcha, Bhutia and Nepali of Sikkim; Meitei, Meitei Pangals, Chothe, Kabui, Kom of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Solanki et al. (2004); Jamir and Lal (2005); Hanse and Teron (2012); Das (2015); Chanu et al. (2016); Borah and Prasad (2017); Dhakal et al. (2019); Jugli et al. (2019).
Weakness (27 species)	*Cervus unicolor* (Sambar), *Macaca assamensis*, *Monopterus cuchia*, *Axis porcinus* (Hog deer), *Bos grunniens* (Yak), *Moschus moschiferus* (Musk deer), *Capricornis sumtraensis*, *Naemorhedus goral*, *Pseudois nayaur*, *Budorcas taxicolor*, *Bos frontalis*, *Vulpes bengalensis* (Fox), *Hoolock leuconedys*, *Columba livia*, *Monopterus* sp., *M. armatus* (Spiny eel fish), *Clarias batrachus* (Walking catfish), *Python molurus*, *Palaemon* sp. (Prawn), *Prionailurus bengalensis* (Leopard cat), *Columba* sp., *Capra* sp., *Wallago attu* (Cat Fish), *Selenarctos* sp., *Varanus bengalensis*, *Civettiictis civetta* (Civet), and *Haliaeetus* sp. (Eagle).	Apatani, Nyishi, Monpa, Tangsa, Wancho of AP; Mizo of Mizoram; Tripuri, Jamatia and Reang of Tripura; Ethnic groups of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Chinlampianga et al. (2013); Das (2015); Devi et al. (2015); Jugli et al. (2019).
Female problems (23 species)	*Chiroptera* sp. (Bat), *Hystrix indica*, *Python molursus*, *Macaca assamensis*, *Rhyticeros undulatus ticehursti* (Wheathead hornbill), *Hylobates hoolock*, *Bos frontalis* (Mithun), *Capra hircus*, *Rattus sp.* (Rat), *Vulpes bengalensis* (Fox), *M. armatus* (Spiny eel fish), *Ursus thibetanus*, *Canis lupus familiaris* (Dog), *Platanista gangetica* (River dolphin), *Monopterus cuchia* (Cuchia fish), *Clarias batrachus* (Magur fish), *Heteropneustes fossilis* (Fish), *Labeo pangusia* (Fish), *Lepus capensis* (Rabbit), *Luthra perspicillata perspicillata* (Otter), *Colisa sota* (Fish), *Manis crassicaudata*, and *Cervus/Machus* sp. (Deer).	Adi, Apatani, Nyishi, Monpa, Galo, Tangsa, Wancho of AP; Biate, Nath, Karbi and Dimasa of Assam; Meitei, Meitei Pangals, Chothe (Lamlanghupi), Kabui (Nambol) Kom communities; Rongmei of Manipur; Mizo, Bru, Chakma of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Kakati and Doulo (2002); Jamir and Lal (2005); Solanki et al. (2005, 2016); Teronpi et al. (2012); Chinlampianga et al. (2013); Betlu (2013); Verma et al. (2014); Devi et al. (2015); Borah and Prasad (2016); Chanu et al. (2016); Ngaomei and Singh (2016); Jugli et al. (2019).

Fractures (11 species)	*M. ursinus* (Sloth Bear), *Pila* sp., *Gallus domesticus* (Chicken), *Hylobates hoolock*, *Xestina* sp., *Sus scrofa domestica*, *Hemitragus jemlahicus*, *Naja* sp. (Cobra), *Hystrix* sp., *Capra sibirica*, and *Aquila rapax* (Eagle).	Nyishi of AP; Ahom, Chutia, Koch-Rajbonshi, Kalita, Adivasis, Nath and Karbi of Assam; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Pochury, Lotha, Khiamniungan, Yimchunger, Chakhesang, Zeliang, and Rengma of Nagaland; Tripuri, Lepcha, Bhutia and Nepali of Sikkim; Jamatia and Reang of Tripura.	Lalramnghinglova (1999); Kakati and Doulo (2002); Solanki et al. (2004); Jamir and Lal (2005); Kakati et al. (2006); Das (2015); Borah and Prasad (2017); Dhakal et al. (2019).
Animal/insect bites (14 species)	*Apis* sp., *Python molurus*, *Hystrix brachyuran*, *Canis lupus familiaris* (Dog), *Viverra zibetha* (Large Indian civet), *Vespa orientalis* (Oriental hornet), *Maydelliathelphusa lugubris* (Freshwater crab), *Eutropis carinata* (Common Indian skink), *Capra hircus*, *Bufo melanostictus* (Toad), *Hylobates hoolock*, *Pheretima* sp. (Earthworm), *Varanus bengalensis*, and *Sus* sp. (Pig).	Apatani, Nyishi, Monpa, Tangsa of Arunachal Pradesh; Biate, Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis of Assam; Ethnic groups of Manipur; Mizo Mizoram; Ao, Angami, Sema, Sangtam, Lotha, Khiamniungan, Yimchunger, Zeliang, Chakhesang, Pochury and Rengma of Nagaland; Lepcha, Bhutia and Nepali of Sikkim.	Lalramnghinglova (1999); Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Betlu (2013); Devi et al. (2015); Borah and Prasad (2017); Dhakal et al. (2019); Jugli et al. (2019).
Anemia (6 species)	*Monopterus cuchia* (Eel Fish), *Bos indicus*, *Hylobates hoolock*, *Clarias batrachus*, *Heteropneustes fossilis* (Catfish), and *Maschus* sp. (Musk Deer).	Karbi of Assam; Meitei, Pangals, Chothe, Kabui, Kom of Manipur; Mizo of Mizoram; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, Pochury and Rengma of Nagaland.	Lalramnghinglova (1999); Kakati and Doulo (2002); Jamir and Lal (2005); Teronpi et al. (2012); Verma et al. (2014); Devi et al. (2015); Chanu et al. (2016).
Male impotency (15 species)	*Muntiacus muntjak* (Barking deer), *Bos grunniens* (Yak), *Budorcas taxicolor*, *Bos frontalis*, *Capricornis sumatraensis* (Serow), *Naemorhedus goral* (Goral), *Pseudois nayaur*, *Gekko gecko* (Tokay gecko), *Passer domesticus* (House sparrow), *Cryptozona bistrialis* (Snail), *Gallus gallus*, *Myotis lucifugus* (Bat), *Canis familiaris*, *Herpestes* sp., and *Aquila* sp.	Apatani, Nyishi and Monpa of AP; Biate, Ahom, Chutia, Koch-Rajbonshi, Kalita and Adivasis of Assam; Rongmei of Manipur; Ao, Angami, Sema, Sangtam, Khiamniungan, Yimchunger, Chakhesang, Lotha, Zeliang, and Rengma of Nagaland; Tripuri, Jamatia and Reang of Tripura.	Jamir and Lal (2005); Kakati et al. (2006); Solanki and Chutia (2009); Betlu (2013); Das (2015); Ngaomei and Singh (2016); Borah and Prasad (2017).
Diabetes (17 species)	*Penaeus indicus* (Prawn), *Puntius* sp., *Scylla serrata* (Crab), *Bufo melanostictus* (Toad), *Tehanochelys trijuga* (Turtle), *Monopterus cuchia*, *Ophiophagus hannah* (King cobra), *Eonycteris spelaea* (Bat); *Ursus thibetanus*, *Capricornis sumatraensis*, *Macaca assamensis*, *Manis* sp., *Petaurista petaurista* (Red giant flying squirrel), *Hystrix* sp., *Uttaney musa* (Mole), *Bos taurus* (cattle), and *Periplaneta americana*.	Adi of Arunachal Pradesh; Rural communities of Dibrugarh, and Biate of Assam; Mizo, Bru and Chakma of Mizoram; Ethnic groups of Manipur; Lepcha, Bhutia and Nepali of Sikkim.	Kalita et al. (2005); Chinlampianga et al. (2013); Betlu (2013); Devi et al. (2015); Solanki et al. (2016); Dhakal et al. (2019).

Table 4. Conservation status (IUCN 2020) of animals used for ethno-zoological applications in NE India

Name of the animal species	IUCN 2020 status
Amblypharyngodon mola (Indian Carpet Fish)	LC
Amphipnous cuchia (Cuchia)	LC
Antilocapra americana (Antelope)	LC
Bufo melanostictus (Toad)	LC
Canis aureus (Golden Jackal)	LC
Centropus sinensis (Greater Coucal)	LC
Chaca chaca (Fish)	LC
Channa punctatus (Snakehead fish)	LC
Civettictis sp. (Civet)	LC
Clarias batrachus (Magur fish)	LC
Columba livia (Pigeon)	LC
Crotalus durissus (Neotropical Rattle Snake)	LC
Cynopterus sphinx (Bat)	LC
Echis coloratus (Viper)	LC
Eutropiichthys vacha (Fish)	LC
Eutropis carinata (Common Indian skink)	LC
Felis silvestris (Wild Cat)	LC
Gallus domesticus (Chicken)	LC
Gekko gecko (Tokay Gecko)	LC
Herpestes sp. (Mongoose)	LC
Heteropneustes fossilis (Singing catfish)	LC
Hystrix indica (Indian Porcupine)	LC
Labeo rohita (Fish)	LC
Lepus capensis (Rabbit)	LC
Lepus nigricollis (Hare)	LC
Lymnaea sp. (Water snail)	LC
Macaca mulatta (Rhesus Macaque)	LC
Mantis religiosa (Praying Mantis)	LC
Martes flavigula (Yellow Throated Marten)	LC
Mastacembelus armatus (Spiny Eel Fish)	LC
Maydelliathelphusa lugubris (Fresh Water Crab)	LC
Megalaima sp. (Barbet)	LC
Mus musculus (House mouse)	LC
Mustela sp. (Weasel)	LC
Mystus bleekeri (Fish)	LC
Naja naja (Cobra)	LC
Nanorana liebigii (Frog)	LC
Petaurista petaurista (Red Giant Flying Squirrel)	LC
Pheretima sp. (Earthworm)	LC
Picus canus (Black Napped Green Woodpecker)	LC
Polypedates leucomystax (Common Tree Frog)	LC
Prionailurus bengalensis (Leopard Cat)	LC
Pseudois nayaur (Himalayan Blue Sheep)	LC
Pteromys sp. (Flying Squirrel)	LC
Puntius sp. (Fish)	LC
Rana sp. (Frog)	LC
Rattus sp. (Rat)	LC
Rhizomys sumatrensis (Bamboo Rat)	LC
Sartoriana sp. (Red Freshwater Crab)	LC
Scylla sp. (Mud crabs)	LC
Struthio camelus (Common Ostrich)	LC
Sus scrofa domestica (Pig)	LC
Talpa sp. (Hill mole)	LC
Varanus bengalensis (Monitor Lizard)	LC
Viverra zibetha (Large Indian Civet)	LC
Viverricula indica (Small Indian Civet)	LC
Vulpes bengalensis (Fox)	LC
Xenentodon cancila (Freshwater Gar Fish)	LC
Arctonyx collaris (Hog badger)	VU
Buceros bicornis (Great Hornbill)	VU
Buceros sp. (Hornbill)	VU
Budorcas taxicolor (Takin)	VU
Cyprinus carpio (Common Carp)	VU
Dicrurus sp. (Drongo)	VU
Haliaeetus sp. (Eagle)	VU
Helarctos malayanus (Malayan sun bear)	VU
Hoolock leuconedys (Eastern Hoolock Gibbon)	VU
Lutrogale perspicillata (Smooth Coated Otter)	VU
Melursus ursinus (*Sloth* bear)	VU
Neofelis nebulosa (Clouded Leopard)	VU
Ophiophagus hannah (King Cobra)	VU
Panthera pardus (Leopard)	VU
Pteropus sp. (Flying Fox)	VU
Python molurus (Indian Python)	VU
Rhinoceros unicornis (Rhino)	VU
Semiplotus sp. (Fish)	VU
Trachypithecus pileatus (Capped Langur)	VU
Ursus thibetanus (Himalayan Black Bear)	VU
Wallago attu (Fish)	VU
Amblyceps sp. (Catfish)	EN
Anguilla sp. (Eel)	EN
Axis porcinus (Hog Deer)	EN
Bubalus arnee (Wild Water Buffalo)	EN
Manis crassicaudata (Indian Pangolin)	EN
Moschus sp. (Musk Deer)	EN
Nycticebus sp. (Slow loris)	EN
Panthera tigris (Tiger)	EN
Platanista gangetica (River Dolphin)	EN
Bagarius sp. (Gangetic Goonch)	NT
Hemitragus jemlahicus (Himalayan Tahr)	NT
Labeo pangusia (Fish)	NT
Macaca assamensis (Assamese Macaque)	NT
Naemorhedus goral (Himalayan Goral)	NT
Pardofelis sp. (Marbled cat)	NT
Testudo sp. (Tortoise)	NT
Chiroptera sp. (Bat)	CR
Geochelone emys (Eastern Hill Tortoise)	CR
Manis sp. (Pangolin)	CR
Callosciurus (Oriental Tree Squirrel)	DD

Note: LC: Least Concern; VU: Vulnerable; EN: Endangered; NT: Near Threatened; CR: Critically Endangered; DD: Data Deficient

Discussion

This study is an attempt to highlight the available knowledge on ethno-zoological therapeutic applications used by different traditional healers and indigenous communities of northeast India. Ethno-medicinal practices have been well known and in use for a long time, but reportedly limited pertaining to studies based on animals in NE India. Such studies on animal-based medicines and their mode of application in NE India are relatively limited and fragmentary due to various reasons that also include the oral transmission of knowledge that gradually declines among local communities. Analysis of literature helped us to discover the traditional cure of ailments with ethno-zoological treatments practiced by various tribes of NE India (Solanki and Chutia 2004; Jamir and Lal 2005; Kakati et al. 2006; Verma et al. 2014).

The present investigation shows that various indigenous communities use animals in their traditional medicines in all of the eight NE Indian states (Table 2-3). In Arunachal Pradesh, the use of animal-based medicines by traditional

healers was never reported systematically earlier, except for a few reports from Pandey et al. (1999), Solanki (2002), Solanki et al. (2004), Solanki and Chutia (2004), Solanki (2006) and Chutia (2006) in the 21st century. A review of literature in Arunachal Pradesh reveals that large-scale use of animal-based ethnomedicine still remained largely undocumented in the state. In Assam, reviews of the available information on ethno-zoological therapeutic procedures and the use of particular organs/body parts of animals for specific diseases are still unexplored and fragmentary; which is believed to be large because local healers share their formulations of therapeutic products with a highly conservative approach. Whole body, meat, soft watery section, etc. are some of the ways the local and traditional healers use animal parts/organ in applying traditional disease healing in Assam. In Manipur, animal parts such as skin, hair, bones, animals and by-products such as urine are usually used in zoo-therapeutic treatments; and secretions of the gland are used in magico-religious and faith-healing rituals; while endoskeletons and exoskeletal parts of animals are used as "charms" to expel evil spirits (Devi et al. 2015).

In Meghalaya, Mizoram, Nagaland, Sikkim and Tripura the application of use of mammals and mammalian products have been observed to be highest, including Arunachal Pradesh and Assam. In Sikkim, Dhakal et al. (2019) stated that parts of the body used in their ethno-zoological medicinal applications included bones, meat, teeth, gall bladder, skin, musks and horns used for dysentery, fractures, tuberculosis, common cough and cold and fever, diabetes, malaria, and piles. In Tripura, Das (2015) had reported that several parts of the body, such as urine, blood, flesh, entire body, feces, etc. are usually used for diagnosis of human ailments depending on the type of ailment and its possible mode of action.

Application of fish-based medicines in the state of Manipur is prevalent compared to other animal species (Figure 4). In Arunachal Pradesh, use of insects is the highest in traditional medicine in comparison to other states (Figure 2). Several other animal groups such as birds, rodents, amphibians, annelids, mollusks, crustaceans, and arachnids are also used for traditional medicines in these communities depending on the type of ailments.

Application of mammals

All NE Indian states, excluding Manipur, recorded the highest use of mammals as compared to other species of animals. Similar findings have also been reported in other parts of India, where use of mammals in traditional medicine is comparatively higher than use of other animal groups (Mahawar and Jaroli 2008). Jaroli et al. (2010) and Chellappandian et al. (2014) were of the opinion that mammals are readily accessible for optimal use in traditional medicine. However, Dhakal et al. (2019) were of the opinion that increased use of mammals may be attributed to the growing number of domesticated mammals and the ethnic communities' association with mammals.

Application of fishes

The review shows that for indigenous communities of NE India, fish have also been the essential resource for traditional medicines, apart from being a good nutrient intake and an integral part of folk ritual. This is evident from the studies conducted in Manipur, resulting in their overuse and thereby leading to over-exploitation (Devi et al. 2015; Chanu et al. 2016). Chanu et al. (2016) stated that the use of *Channa orientalis* in different types of traditional medicines and religious purposes is one of the reasons for drastic reduction of this fish species in the natural habitats. Another example is the use of *Channa orientalis* and *Channa punctatus* as 'goodwill charms' amongst some tribes in Manipur during marriage ceremonies, New Year's Day of Meitei tribes, taken in fermented forms by ailing patients. The skin, eyes, whole body, flesh and scales are widely used body parts of fish for therapeutics. (Devi et al. 2015).

Application of insects

In addition to mammals and fish, insects were also observed as one of the most important sources of ethnomedicine in NE India. Traditional knowledge and acceptance of insects as food and for local therapies have been found to be highly prevalent in Arunachal Pradesh (Dagyom and Gopi 2009; Chakravorty et al. 2011a), Meghalaya (Mihsill and Keshan 2011) and with lesser use in other states of NE India. It is observed that insects are used during the larva stages, pupal stages and also in adult stages in traditional medicine (Chakravorty et al. 2011a). Rodriguez and Levin (1976) believed that since insects and plants use similar chemical compounds for defense mechanisms, the use of pharmacological activities from such insect species that feed on plants producing drugs becomes a potential source of ethno-zoological medicines.

Application of animal body parts

Flesh, meat, bones, bone marrow, fats, gall bladder, food pipe, reproductive organs, horns, feather and legs of birds, animal fetuses, fat, hair, skin, liver, teeth, musks, ears, tongue, neck, hands, arms, skin and male organs are widely used in NE India (Table 2). It is also observed that in ethnomedicine animal products like urine, blood, bile juice, milk, and soft watery portions were used.

The review shows that there is still lack of research on traditional medicines based on animals by the indigenous communities of NE India, especially in the state of Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (Table 2-3). Further, documentation needs to be carried out with respect to traditional medicines based on animals by Garo, Jaintia and Bhoi communities of Meghalaya. Use of elephant teeth in food poisoning by the Khasi community of Meghalaya needs to be documented.

CONCLUDING REMARKS

Traditional medicine using animals has been playing vital roles in the ethnic health care system for ages. However, equally vital is the fact that taking utmost care of

ecological balance while practicing traditional medicines using animals and animal products requires attention to conserve our rich biodiversity. Gradual changes in eco-system patterns as a result of deforestation, jhum farming, uncontrolled fishing, etc., lack of awareness of conservation and preservation, and other factors, have posed serious threat to the existing ethnomedicinal plants and animals in NE India (Yirga et al. 2011). The traditional ethnomedicinal practices require prompt recognition by authorities and further strengthening with the help of incentivized training and education programs (Dhakal et al. 2019). Creation of database on the practitioners and the mode of treatment would prioritize creation of policies and regulations thereby enforcing a safeguard on natural resource exploitation. Responsible roles by the traditional healers while practicing local medicine would lead to an effective balance between nature and traditional medicine. An integrated approach towards potential uses of traditional medicine using animals would not only conserve our rich natural resources, but also aid in preserving cultural heritage as well. For aquatic species, a conservation and sustainable strategy need to be implemented while utilizing these species for traditional health practices. Additionally, scientific awareness, management and conservation measures of animal resources would enhance better connectivity with nature.

NE India accounts for only 8% of the geographical area of India; however, around 60% of the country's endangered species flourish in the region (Choudhury 2006). There are many species that are native to this area, such as the Indian Rhinoceros, Wild Buffalo, primate species, etc., used for ethno-zoological applications. Several primates are reportedly believed to have been hunted in Arunachal Pradesh, Assam, Mizoram, and Tripura, and for several superstitious beliefs and possession of medicinal properties (Gupta et al. 2014). Aiyadurai (2011) recorded that out of a total of 50 native Indian species of Galliformes (land fowls), 32 occur exclusively in NE India. The share of NE India is relatively high in the case of 'Vulnerable' birds and reptiles: 74% and 80% respectively (Choudhury 2006). Gupta et al. (2014) recorded that 11 of the 16 primate species in India are recorded to live in NE India; and with the exception of three species, due to many anthropogenic activities, remaining primate species have faced serious threats. As recorded by Gupta et al. (2014), other species known to be endangered in North-eastern states due to several anthropogenic pressures include slow loris, tiger, leopard, bear, serow, goral, yak, sheep, pangolin, river dolphin and several bird and reptile species. Present study also reflects that several vulnerable, endangered, near threatened and critically endangered species are being used for ethno-zoological applications in NE India (Table 4).

Wildlife hunting poses a high risk to the survival of wildlife species in this area due to the fact that indigenous communities of the North-East are largely dependent on ethnozoological applications for traditional medicine (Aiyadurai 2011; Gupta et al. 2014). A major reason why wildlife hunting is seen as a difficult problem to address is the relation between hunting and the socio-economic needs of local people; and the same balance needs to reduce the adverse effect of hunting on wildlife populations and the reliance of rural communities on wildlife for food, medicine, etc. (Aiyadurai 2011). Long-term conservation measures such as education, eco-tourism, and the establishment of more protected areas may be necessary to provide a sustainable existence of ethnomedicinal applications as well as the conservation of endangered species in order to cover as much habitat as possible and to check for habitat destruction, fragmentation, deforestation, wildlife hunting and pollution, which are critical to the existence of diverse species in the region. In addition, a database of available species will provide a deeper understanding of the conservation strategy and of the region's species composition.

The traditional healers need to be sensitized and made aware of the extant Acts and Rules pertaining to wildlife conservation (Tynsong et al. 2020). However, ethno-zoological application of animals is a matter of serious concern connected with illegal trade in wildlife where animal parts/animal products such as gall-bladder of Himalayan Black Bear, goral horns, pangolin scales, monkey flesh, etc. are rarely available (Dhakal et al. 2019). Reports indicate that subsequently, scarcity has led to a decline in ethno-zoological traditional medicines among indigenous communities in Sikkim (Dhakal et al. 2019). Studies conducted by Dhakal et al. (2019) also suggest amphibian species such as *Nanorana liebegii* and *Amolops himalayanus* have a high value of ethnomedicinal properties in zoo therapy and are therefore prone to overexploitation.

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