Indian Forester, 143 (10) : 969-974, 2017
http://www.indianforester.co.in

ISSN No. 0019-4816 (Print)
ISSN No. 2321-094X (Online)

EARTHQUAKE EARLY WARNING THROUGH ABNORMAL ANIMAL BEHAVIOUR

S.P. VASUDEVA

Principal Chief Conservator of Forests (HoFF) (Retd.) Himachal Pradesh
E-mail: spvasudeva@yahoo.com

ABSTRACT

Earthquake is one of the most destructive natural hazards causing destruction. However, there is no early warning and forecasting system in place unlike cyclones, floods and tsunami. It is usually predicted seconds before it strikes through instruments installed for this purpose when managing the destruction is not possible. Animals behaving strangely which is not usually normal before an earthquake have been reported. There is need to standardise this abnormal animal behaviour in such a way that it always gives uniform results and if need be in linking with instruments so as to consider it as a reliable and sure early warning before the earthquake strikes. This is urgently required so as to reduce risks that cause loss of lives and properties.

Key words: Bureau of Indian Standards (BIS); Indian Meteorological Department (IMD); U.S. Geological Survey (USGS).

Introduction

An earthquake is a sudden shaking of the earth crust for a limited time in an area, when one of the earth plates moves against other to cause so much tension that rocks cracks to cause consequent destruction. Earthquake has been defined as most dreaded natural disaster, especially for its intrinsic nature to unleash devastation instantaneously in large area, without leaving much scope for prevention of hazard after the occurrence of event (IMD, 2014). More than 50,000 people die every year worldwide due to earthquakes. According to the latest seismic zoning map brought about by Bureau of Indian Standards (BIS) over 65% of India is prone to earthquakes. Earthquake prediction system must consist of early and accurate forecasting of its size, place and time of occurrence (Agarwal, 1991). The prediction of earthquake much before its occurrence at present is difficult. It is therefore necessary to develop an early warning and forecasting system for prediction of size, when and where earthquakes would strike so as to reduce the involved risks. In India prediction of earthquake through instruments is being done by Indian Meteorological Department (IMD) Delhi and its offices located at various parts of the country.

Earthquakes are reported to be generally preceded by signals divided into geographical precursors and abnormal animal behaviour. Although lot of research has been carried on the former aspects but latter subject has not been studied to the level it can help in early prediction of earthquakes. Animals' behaving strangely and abnormally which is not usually normal before a large earthquake strikes has been reported in insects, fish, reptiles, birds and mammals (Tributsch, 1982). This is depicted by animals through sensory organs having much more capacity of perceiving geophysical stimuli than human beings (Bhargava *et al*., 2009). The changes in behaviour of animals prior to earthquake have recently been captured and documented that may assist in early forecasting of earthquakes (Grant *et al*., 2011). Animals can thus be considered as messengers of nature in predicting earthquake. Chinese and Japanese scientists pioneer in this field have observed and recorded such abnormal animal behaviour and have tried to develop an earthquake early warning system with some success (Allen, 1976). Most unusual animal behaviour in 38 earthquakes that occurred between 1923 and 1978 in Europe, Asia and Americas were observed near epicentre within 1 or 2 days of its occurrence. Such behaviour was mostly recorded in domestic animals but fish and snakes also depicted it more than a week in advance at some distance (> 50 kms) from the epicentre (Buskirk *et al*., 1981). In India work on abnormal animal behaviour in predicting earthquakes has been reviewed (Bhargava *et al.*, 2009; Lakhmi *et al*., 2014).

Abnormal behaviour of animals in the past has been ignored by scientists, regarding it as folklore. The scientific basis of such behaviour has been summarised in the "Proceedings of 1976 US Geological Survey (USGS) Conference on Abnormal Animal Behaviour Prior to Earthquakes" (Evernden, 1976). The most creditable

Standardising the abnormal animal behaviour is needed to show uniform result to utilize as a predictive response for early warning of earthquakes.

evidence comes from a five year study conducted by Stanford Research Institute "Project Earthquake Watch" which obtained statistically significant results on abnormal animal behaviour prior to earthquakes (Otis and Kautz, 1985). In view of work done and being done there is need to develop an early warning and forecasting system based on exhibited abnormal animal behaviour for predicting earthquakes to reduce and mitigate the risks that causes destruction.

Abnormal animal behaviour and forecasting of earthquakes

Animals have sensory perceptions which human beings don't possess on the basis of which they have better power of sniffing, hearing, seeing and sensing. The hearing range is 67 to 44,000 Hz in dogs, 55 to 79,000 Hz in cats and 31 to 17000 Hz in human beings (Heffner, 1998). Therefore dogs and cats can hear ultrasounds that human beings can't. The number of small receptors, olfactory cells of dogs and cats are much more and numerous than 12 million in human beings (Shier *et al*., 2004). The olfactory bulbs of dogs contain approximately 280 million cells, cats have 67 million with human beings only with 5-20 million (Hart, 1977; Beadle, 1977). Dogs can detect odour concentration of 10-17 molar compared to only 10-4.5 to 10-5 molar in human beings (Halasz, 1990). These sensory perceptions are exhibited before an earthquake through various behaviour changes in different animals and can be used for prediction of earthquakes.

The earliest reported case of abnormal animal behaviour observed five days before the earthquake destroyed the Greek city of Heleke is by Roman historian Aelianin in 373 BC, when animals like centipedes, snakes, rats etc. usually living below ground emerged and left the city. In India first such report on abnormal behaviour of animals was reported at Govindpur (Manbhoom,) on 19th February, 1892, wherein it was seen that dogs sniffed the ground and exhibited nervousness. During recent earthquakes of Uttrakashi (1991), Latur (1993), Jabalpur (1997), Chamoli (1999) and Bhuj (2001) unusual behaviour of dogs was noticed and reported (Lakshmi *et al*., 2014). In 1855 and later in 1923 before earthquake of Edo (Modern Tokyo) catfishes which usually lie buried underground acted weird, exhibiting increase in their activity by swimming to the surface of ponds and rivers (Hatai and Abe, 1932; Musha, 1957; Tributsch, 1982). Giant oarfish which are snakelike and normally live in very deep sea waters are believed to come up on surface waters near coasts and Japanese believe that this feature is prediction of the ensuring earthquake (Tong, 1988). In China 58 species of animals such as snakes, bats, rodents have been considered useful in predicting earthquake on which booklets have been prepared (Tong, 1988).

The Haicheng Earthquake of China of magnitude 7.3 that struck on 4th February 1975 was predicted successfully as early as mid December, 1974 through abnormal behavior of animals such as snakes and rats that came out of hibernation and froze on snow. Similar abnormal activities of rats and snakes were observed in January, 1975 which further intensified in first 3 days of February, 1975 when bigger animals like cows, horses, dogs and pigs also showed erratic behavior before earthquake of magnitude 7.3 struck on 4th February, 1975. The loss of lives would have been much more but for evacuation of 90,000 people from the city before the earthquake due to observed abnormal behavior of animals (Tong, 1988). There were reports of unusual animal behaviour before Tangshan earthquake in China of magnitude 8.2 struck in 1976, wherein due to non issuing of warning 2,40,000 people died (George, 2007). These findings suggest that earthquakes do not always come without warning that is required to be tapped for developing an early warning and forecasting system.

Scientific insight into possible connection between abnormal animal behaviour and earthquake began after visit of U.S. seismological team to China in 1975 to study work done in predicting 7.3 earthquake in city of Haichang. Thereafter U.S. Geological Survey (USGS) as already indicated sponsored a conference on "Abnormal Animal Behaviour Prior to Earthquakes" in 1976 held at Menlo Park, California and work on this aspect is continuing since then in many countries especially China and Japan. There are reports from western world as well where animals have been reported to show abnormal behaviour hours and days before earthquake strikes. In Halan province of Friaul one day before earthquake of 6.5 struck on 6.5.1976 mice were observed running in open spaces and farm animals showed signs of restlessness. In Virginia before earthquake of magnitude 5.8 struck on 23.8.2011, in adjoining Smithsonian National Zoological Park in Washington animals showed restlessness and Apes were seen climbing trees. James Berkland a geologist of USGS predicted earthquakes with more than 75% accuracy by counting number of lost pets advertised in daily newspapers. He co-related this with lunar tide cycle. He concluded that the number of pet cats and dogs lost as per calculation from daily newspapers went up 2 weeks before the earthquake strikes. However, in view of publication of an article in California Geology in 1988 based on statistical analysis of this data it was concluded that there is no co-relation between lost pet ads and earthquakes.

Survey done in China has shown that largest

number of cases of abnormal behavior of animals precedes 24 hours before an Earthquake strikes. In other cases where major earthquakes have preceded by foreshocks, such behavior in rats, fish and snakes was observed as early as 3 days prior to earthquake, but continuing for several hours, or even few minutes before earthquake actually struck. Scientific instruments installed for warning earthquakes can however predict few seconds before these strike instigating the scientific community to work on this aspect of abnormal animal behavior for developing an early warning and forecasting system for earthquakes wherein prediction can be done much in advance. Such early warning systems are already in place for floods, cyclones and Tsunamis.

Defining unusual animal behaviour

Defining unusual animal behaviour is not a simple clear process wherein a uniform marked behaviour of animals before an earthquake strikes has to be attributed to because such behaviour can also be depicted due to non-seismic reasons. However, some distant patterns observed in various animals before earthquake mostly reported by Tributsch (1982) are an intense fear that makes some animals cry and bark for hours or flee in panic or appearing confused or agitated, excited, nervous, overly aggressive, or seem to be trying to borrow or hide. Further, deep sea fish appearing on surface of sea around Japan, some fish especially catfish have been reported to leap out of water to dry land; snakes come out of hibernation during snowy winter to freeze in view of low temperature; mice appear to be dazed and can be easily caught by hand; pigeons are said to take longer to fly to their destination; hens have been reported to be laying fewer or no eggs at all; pigs have been seen aggressively biting each other. In addition appreciable decrease in yield of milk of cows and bees leaving their beehives in panic minutes before and returning only 15 minutes after the earthquake have also been reported (Miller, 1996).

The Group of Earthquake Research Institutes of Biophysics China (1979) after extensive survey of abnormal animal behaviour before a strong earthquake have concluded

i) Most animals show increases restlessness before an earthquake.

ii) The precursor time varies from a few minutes to several days, with increased restlessness at 11 hours which becomes still more marked about 2 to 3 hours before the earthquake. In general precursor times of various animals are mostly within 24 hours before the earthquake.

iii) These observations have been noticed predominantly in high intensity or epicentre region close to active faults.

iv) Abnormal animal behaviour is observed during earthquakes of magnitude of 5 or more.

Such strange abnormal animal behaviours has been explained to be due to seismic P waves that travel at more than double the speed through the earth crust and arrive before S waves which strike later to cause destruction and can be felt by humans (Buskirk *et al*., 1981). Animals living far away from the epicentre on detection of P waves escape from the area to avoid the effects of destructive and energetic S waves (Pease and Orourke, 1997). To be absolutely sure such abnormal behaviour has to be standardised to always show uniform pattern to be defined and used for sure as early warning for earthquakes. If required it can be combined with data of other disciples through instruments that detect P waves to give uniform conclusive prediction which can be considered as early warning for earthquakes much before these strike. The studies need to be taken forward through constitution of team of biologists, biophysicists, geophysicists, seismologists along with wildlife experts to bench mark and standardise reliable abnormal animal behaviour for predicting earthquake much earlier than instruments can forewarn. In India such a task can be assigned to Wildlife Institute of India, Wadia Institute of Himalayan Geology and Indian Institute of Remote Sensing all luckily located at Dehradun in Uttarakhand for such a purpose.

Theories on warning of earthquake due abnormal animal behaviour

The following theories on prediction of earthquake due to precursory signals that animals detect thereby depicting abnormal animal behaviour have been reported.

Earth's vibration

Some animals can sense earth's vibrations set in due to initiation of earthquake wherein they display unusual behavior. It has been suggested that they are responding to P-waves, as these travel twice as fast as S-waves that actually cause severe shaking of land and consequent destruction (Buskirk *et al.*, 1981; Pease and Orourke, 1997). This response of P-waves cannot be termed as predictive response but an early warning system (Kirschvink, 2000). It is reported that snakes can sense vibrations and infrared radiations caused due to earth vibration on onset of earthquake and depict these through their abnormal behavior.

Changes due to release of chemicals

Animals can sense chemical changes in ground water when an earthquake is about to strike. Scientists initiated studies into these chemical effects after observing colony of toads abdomen ponds in ''L'Aquila, Italy'' in 2009, days before an earthquake struck (Grant and Halliday, 2010). It was suggested that stressed rocks in the Earth's crust release charged particles that react with ground water. Animals highly sensitive to chemical changes that live in or near ground water can detect these through their sensory organs and react abnormally before rocks finally slip to cause an earthquake.

Thermal variations

Snakes can detect thermal variations reported to occur before an earthquake strikes, and shows it through coming out of hibernation even during winters. Such behaviour of snakes was observed during the Haicheng Earthquake of China in 1975.

Ultrasound

It has been suggested that some animals react to ultrasound emitted as micro-seism from fracturing rock due to onset of earthquake (Armstrong, 1969) and depicting it through abnormal animal behaviour.

Piezo-electric effect

Tributsch (1982) has suggested that piezoelectric effect of quartz that constitutes 15% or even more (up to 55%) of the earth crust is capable of generating electric energy to generate air borne ions before and during the earthquake and electrostatic charging of aerosol particles are reacted to by animals in depicting the abnormal behaviour. Tributsch (1982) has suggested an electrical link to abnormal behaviour in fish and other aquatic animals before earthquake.

Earth magnetic field

Some animals have sensitivity to variations in earth's magnetic field. Ikeya *et al*., (1996) has investigated the ground electric field effects caused due to earthquake on behaviour of some animals. These variations in the magnetic field occur near the epicentre of earthquake (Chapman and Bartels, 1940) and are picked up by animals and depicted through their abnormal behaviour (Otis and Kautz, 1985; Hayakawa, 2013).

Marsha Adams in San Francisco USA claims to have developed sensors that can detect low frequency electromagnetic signals that allow predicting earthquake with about 90% accuracy. These signals are generated by fracturing of crystalline rocks deep in the earth along fault lines which are biologically active and instruments developed by her are picking up signals in the same way as sensitive animals do (Brown, 1996) to depict abnormal behaviour. However, such instruments are still trade secrets and have not come into market.

Conclusion and Discussion

Earthquake is one of the most destructive natural hazards which cannot at present conclusively be predicted in advance. Therefore there is need for developing an early warning and forecasting system so as to reduce the risks involved by warning in time before the earthquake strikes to cause destruction. The observation of abnormal animal behaviour in different categories of animals before an earthquake has been reported (Tributsch, 1982). Animals have sensory perceptions that human beings don't have which are employed by them and depicted through their abnormal behaviour. The Group of Earthquake Research Institutes of Bio-physics China (1979) after extensive survey have come up with some uniform pattern of abnormal animal behaviour shown before a earthquake of intensity of more than 5 strikes. This abnormal behaviour in a particular animal has to be standardised which need to be uniform whenever an earthquake strikes and is different from such a behaviour in normal times. Berkland had suggested two primary precursory earthquake signals, P waves which come about a week before and other S waves that come just moments before the earthquake to cause destruction. The peaks observed in instruments in the form of P waves as explained by Kirschvink (2000) have to be linked with the abnormal animal behaviour (as these also respond to P-waves) and standardised to be always showing uniform results to be utilised as a predictive response for early warning of earthquakes. The abnormal behaviour of animals – pets and domestic, those in zoos and in wild so standardised should be linked with instruments which are capturing P waves in showing absolute compatibility to be doubly sure that such a behaviour can be used for early warning and forecasting of earthquake. Beginning in this respect has already been made by Marsha Adams in USA (Brown, 1996) which has to be taken forward as discussed in developing and early warning and forecasting system for earthquakes. Work in this respect is going on in China, Japan and Americas but India with a vast network of research institutes must take initiative to develop such an early warning and forecasting system like those developed for cyclones, tsunamis and floods as more than 65% of the country is prone to earthquakes.

भूकंप-असामान्य पशु व्यवहार के जरिए पूर्व चेतावनी

एस.पी. वासुदेवा

सारांश

भूकंप विनाश उत्पन्न करने वाले सबसे विनाशक प्राकृतिक संकटों में से एक है। तथापि, चक्रवात, बाढ़ एवं सुनामी से भिन्न पूर्व चेतावनी देने और भविष्यवाणी करने की कोई प्रणाली मौजूद नहीं है। इस उद्देश्य के लिए स्थापित उपकरणों के जरिए इसके घटित होने से कुछ सैकेण्ड पूर्व सामान्यत: इसकी भविष्यवाणी की जाती है, जब विनाश का प्रबंधन कर पाना संभव नहीं होता है। भूकंप आने से पूर्व पशुओं में होने वाले विलक्षण व्यवहार सूचित किया गया है। इस असामान्य पशु व्यहार को इस तरह से मानकीकृत करने की आवश्यकता है कि यह हमेशा एक समान परिणाम दे और यदि आवश्यक हो तो उपकरणों के साथ जोड़ा जाए ताकि इसे भूकंप आने से पूर्व एक विश्वसनीय एवं सुनिश्चित पूर्व चेतावनी के तौर पर समझा जा सके। इसकी तत्काल आवश्यकता है ताकि उन जोखिमों को घटाया जा सके, जो जान-माल को भारी क्षति पहुँचाते हैं।

References

Agarwal P.N. (1991). Engineering seismology. Oxford and IBH Publishing Company Pvt. Ltd. New Delhi.

Allen C. (1976). The Role of animal behaviour in the Chinese earthquake prediction program. In: Abnormal animal behaviour prior to earthquakes.

Armstrong B.H. (1969). Acoustic emission prior to rockbrust and earthquakes. *Bull. Seismol. Soc. Am.,* 59: 1259-1279.

Beadle M. (1977). The Cat: History, Biology and Behaviour. Simon and Schuster. New York, NY, USA.

Bhargava N., Katiyar V.K., Sharma M.L. and Pradhan P. (2009). Earthquake prediction through animal behaviour. A review. *Indian J. Biomechanics, Special Issue (NCBM)* 7-8: 159-165.

Brown D.J. (1996). Interview with Marsha Adams unpublished.

Buskirk R.E., Frohlich K. and Litham G.V. (1981). Unusual animal behaviour prior to earthquakes. Review of possible sensory mechanisms. *Rev. Geophy. Space Phy.,* 19: 247-270.

Chapman S. and Bartels J. (1940). *Geomagnetism* Vol. 1. Clarendon Press, Oxford.

Evernden J.F. (1976). *Abnormal animal behaviour prior to earthquakes*. US department of interior geological survey conference I. Convened under the auspices of the National earthquake hazards reduction program, USGS, Menlo Park, CA. 23-24.

George P.C. (2007). Can animal predict earthquake. Tsunami pages of George PC. www.dr.georgepc.com.

Grant R.A. and Halliday T. (2010). Predicting the unpredictable; evidence of pre-seismic anticipatory behaviour in the common toad. *J. Zoology,* 281: 263-271.

Grant R.A., Halliday T., Balderer W.P., Leuenberger F., Newcomer M., Cyr G. and Freund F.T. (2011). Ground water chemistry changes before major earthquakes and possible effects on animals. *Int. J. Environ. Res. Public Health*. 8: 1936-1956.

Halasz N. (1990). Vertebrate olfactory system. Akaderniai Kiado: Budapest, Hungary.

Hart B.L. (1977). Olfaction and feline behaviour. *Feline Pract*., 7: 8-10.

Hatai S. and Abe N. (1932). The response of catfish, *Parasilurus ascotus*, to earthquake. *Proc. Imper. Acd. Japan*, 8: 374-378.

Hayakawa M. (2013). Possible electro-magnetic effects on abnormal animal behaviour before an earthquake. *Animals*, 3: 19-32.

Heffner H.E. (1998). Auditory Awareness. *Applied Animal Behaviour Science,* 57: 259-268.

Ikeya M., Furuta H., Kajiwara N. and Anzai H. (1996). Ground electric field effects on rats and sparrow: Seismic Anomolous Animal Behaviour (SAABs). *Japanese J. Appl. Physics,* 35: 4587-4594.

IMD (2014). *A report on seismic hazard micozonation of NCR Delhi* on 1:10,000 scale center for seismology (Indian Meteorological Department), Minsitry of Earth Sciences, Govt. of India, March 2014, New Delhi. India.

Kirschvink J.L. (2000). Earthquake prediction by Animals: Evolution and sensory perception. *Bulletin of the Seismological Society of America,* 90(2):103-118.

Lakshmi K.R., Y. Nagesh and Veera Krishna M. (2014). Analysis on predicting earthquakes through abnormal behaviour of animals. *Inter. J. Scientific and Engineering Research,* 5: 845-857.

Miller T. (1996). Earthquake prediction handbook. Info-Pub.

Musha K. (1957). Jishin Namazu (Earthquake and Catfish). *Toyotosho. Tokyo.* 208.

Otis L.S. and Kautz W.H. (1985). *Biological premonitors of earthquakes; validation study*, final report. Office of earthquake studies. US Geological Survey. Menlo Park. CA. Sri. International.

Pease J.W. and Orourke T.D. (1997). Seismic response of liquefaction sites, *J. Geotech Geoenvrion. Eng.,* 123: 37-45.

Shier D., Butler J. and Lewis R. (2004). *Hole's Human Anatomy and Physiology*, 10th Ed. McGraw-Hill: Boston, MA, USA.

Tong W.K. (1988). *Abnormal behaviour and the prediction of earthquakes*. Phd. Thesis Northestern Illinois University.

Tributsch H. (1982). When the Snakes Awake: Animals and Earthquake Prediction. MIT Press, Cambridge, *Massachusetts*. 248.