

2

Precursors Before Recent Earthquakes

Kobe, Izmit, Taiwan and India



This catfish was photographed moving violently in its tank 20 hours before the Geiyo Earthquake (M6.7) on March 25, 2001, about 240 km from the epicenter. The normal behavior of a catfish is a motionless, resting state.

2.1 Introduction

After the 1995 Kobe Earthquake people in the area were asked to report any unusual phenomena they had observed before the quake. Their reports, gathered by mass media, letter, fax, phone and Internet, were published as a book, *1519 Statements: Precursors of the Kobe Earthquake* (Wadatsumi, 1995), which contained illustrations and photographs of earthquake lightning, vapor trails, elongated and red moons and unusual animal and plant behavior. The book was dismissed by some scientists as meaningless and misleading, but soon after the quake the Kansai Science Forum set up an interdisciplinary sub-forum whose brief was to study information on earthquake precursors with a view to saving lives. Its 40 members included physicists, seismologists, geologists, zoologists, telecommunications and information scientists and industrial sociologists.

Unusual phenomena were observed before the Izmit Earthquake in Turkey (Ulusoy and Ikeya 2001) and the Taiwan-921 Earthquake in 1999 (Ikeya *et al.*, 2000c). Questionnaires seeking more information were distributed in refugee centers and villages at the epicenters one month after the earthquake in Turkey and three months afterwards in Taiwan. Newspaper articles reporting unusual phenomena were also collected.

At the author's request, Dr H. K. Kundu (Geological Survey of India, Calcutta), investigated reports of unusual phenomena before the Gujarat Earthquake in India in 2001, and BBC listeners in Britain and the USA personally reported to the author their experience of unusual pre-earthquake phenomena after he appeared in the program: *Tomorrow's World*. Most of the accounts closely resembled the ancient legends and reports collected after the Kobe quake.

As already mentioned, in our technological age a new phenomenon is being reported: the unusual behavior of home-electric appliances before earthquakes. Clocks either stopped or their hands rapidly rotated, in either direction; radios, TVs, and air-conditioners suddenly switched themselves on, mobile phones rang but left no caller details. Naturally enough these odd stories invited comment ranging from the hilarious to the cynical.

Rikitake gave the name *macroanomalies* to unusual phenomena before earthquakes and collected stories about them from Japanese literature. These stories were indexed for epicentral distances and precursory times against earthquakes in China, San Francisco and other parts of the USA, countries of the former Soviet Union, Rumania, former Yugoslavia, Turkey, Italy and Central and South America (Rikitake, 1976, 2001). The database is helpful to scientists attempting to set up experiments or theories to test the possibility of a scientific basis to precursor stories.

The following reports from the Kobe, Izmit, Taiwan and Indian earthquakes are hopefully useful additions to Rikitake's database. Following sociological practice they have not been edited, because editing usually raises criticisms about the criteria for exclusion. They are the raw material, essentially as gathered from observers and survivors, and will appear naive and ill-founded in many cases. However, the reader is asked to look for common threads. It is these threads that are the subject, in *Earthquakes and Animals*, of scientific experiments and a hypothesis developed around an electromagnetic (EM) model of a geological fault.

2.2 What happened before the Kobe Earthquake?

2.2.1 Over 2000 statements on earthquake precursors

The Kobe Earthquake (M7.3) that occurred at 5:47 a.m., January 17, 1995, was caused by the movement of the Nojima fault on Awaji Island. Total official casualties were 6433, and over 40,000 were injured. The 1519 statements (1711 cases) on precursors collected by Wadatsumi (1995) through the mass media were mostly from the surrounding areas and can be classified thus:

Unusual animal behavior	872 (51%)
Sky and atmosphere	490 (29%)
Sea and land phenomena	189 (11%)
Electric appliances	149 (9%)

The Kansai Science Forum collected 173 statements from the epicenter (which Wadatsumi was unable to collect in the immediate post-quake confusion), but they were essentially the same as those he had already collected and similar to those described in Japanese legends and proverbs. As mentioned, the unusual behavior of home-electric appliances was a new feature.

2.2.2 Phenomena in the sky and atmosphere

(a) Earthquake light (EQL: 8 % of sky and atmosphere reports)

Figure 2.1 shows a photograph of the western sky in the morning under EQL. The sky again became dark almost immediately afterwards and the earth trembled. The phenomenon was observed almost coseismically by many people including graduate students and two colleagues, both professors. Other similar effects were seen before and after the quakes though it is difficult to distinguish these from lightning associated with thunderstorms.

(b) Earthquake clouds (EQCs) and earthquake fogs (EQFs) (44%)

Vapor trails (contrails): Photographers who photographed these at the time of earthquakes often claimed these were earthquake clouds (See Figure 2.1).

Tornado-like clouds: Some were photographed eight days before the earthquake (See Figure 2.2). Such clouds, some photographed half a day before the earthquake, and shown in the color plates, are discussed in Chapter 7.

Fogs: In spite of cloudless fine weather in the Kobe area before the earthquake, fogs were nevertheless observed in the region around Nishinomiya City, east of Kobe preceding the quake (Tsukuda, 1997). There were also reports of local rain from lay citizens, which puzzled a meteorologist in the Kansai Science Forum because it was quite inconsistent with the local weather conditions at the time.

(c) Sun, stars and moon (25%)

Sun: The morning sun looked unusually yellow.

Moon: The moon looked elongated (See Figure 2.3. Clouds appear to the left and bottom of the moon).

Stars: Stars felt so near that they could be touched.

2.2.3 Unusual animal and plant behavior

The following percentages are Wadatsumi's.

(a) Mammals (324 reports; 38% of reports on animals)

The Japan Pet Care Association distributed questionnaires to 210 owners living in 68 shelters in Kobe and found that more than one third ($15/38 = 39\%$) of cats and one fourth of dogs ($39/149 = 26\%$) behaved in unusual ways at the epicenter (Sugihara *et al.* (ed.), 1998).



Figure 2.1 Earthquake light (EQL) shown in a photograph of the western sky before the Kobe Earthquake, (Wadatsumi, 1995). Vapor trails are also seen in the photograph (Photo: N. Yokota near Kansai Airport).



Figure 2.2 A tornado cloud photographed eight days before the Kobe Earthquake (Wadatsumi, 1995). A similar one was observed a day before the quake (See front color plates). (Photo: Ms T. Sugie.)



Figure 2.3 A photograph of an elongated moon with background clouds, taken at 8 p.m. on Saturday, January 16, a day before the Kobe Earthquake (Wadatsumi, 1995). (Photo: Mr H. Yamamoto.)

Dogs (113; 15 %): Many stories from Japan, China and Europe tell of dogs saving human lives by drawing people outside before a disaster. In one TV account a man said he owed his life to his dog sleeping beside him before the earthquake. Other dog behaviors a day before the quake were described as puzzled or protective—as if a stranger were nearby. Some howled like wolves. Others refused to be separated from their owners, either insisting on staying inside or trying to get the owner outside sometimes early in the morning. Some left home before the earthquake and only returned several days later, with other dogs. Some dogs near the epicenter barked continually up to 30 minutes before the earthquake, waking their owners. Some dogs hid in corners, one in a bookshelf before the aftershocks. Others suddenly began to scratch at the floor or to dig up soil.

A neighbor said that for a week before the quake her dog refused to take its usual route towards the future epicenter area on its regular walks. Dogs often seemed to want to snuggle with owners just before aftershocks. The same dogs were also anxious before thunderstorms.

Cats (81; 11 %): Some cats tried to get into bed with their owners, waking them up; some bit their owners. Forty-five minutes before the quake others meowed to be let out of the house. Four abandoned cats, which usually appeared for food, didn't come the day before the quake but turned up afterwards at the family's half-demolished home. One cat, a Russian blue, usually gentle in nature, was violent one hour before the quake.

Sea lions (1) Zoo-keepers reported odd behavior by sea lions at the Kobe Oji Zoo about 25 km away from the north edge of the stressed Nojima Fault. They cried, refused to eat, jumped about, swam in zigzags and fussed. In a BBC report, *Tomorrow's World*, their keepers made jokes about an imminent large quake. An experiment on these sea lions is described in Chapter 4.

Hippopotami in the zoo submerged themselves before the quake and refused to surface for three days, according to the zoo's director, Dr M. Gondou. Their nervous keepers finally drained the pool and found them alive.

Squirrels: Zoo squirrels were found dead in their burrows after the quake.

Rats (63; 25%): A local rat trap caught a total of seven rats four days before the quake; the usual quota was none or one. People reported increased scuffling from rats before the quake, then they seem to have disappeared.

Hamsters either bit each other or their owners; some kept quivering—presumably in fear.

Rabbits: A fat rabbit, which rarely hopped or moved, suddenly became active.

(b) Human (91; 12 % of reports on animals)

Fatigue and irritation: A local professor noted in his diary a day before the quake that he had felt uncommonly tired and irritable that day.

Sickness, nausea, dizziness and sense of imbalance: Some people near the epicenter area reported symptoms such as dizziness, vomiting, motion sickness, hyperventilation, headache, fatigue and nervous irritability a day before the quake.

Strange odor: There were reports of a strange smell about 35 km away from the epicenter.

Cold touches: There were reports of a sensation like a cold touch on the cheek, tree leaves rustling when there was no air movement, and low frequency sounds just before the earthquake. The author noticed an ozone smell—always produced by high voltages—just before the quake.

Early waking: Many people in the earthquake zone said they had woken at about 5 a.m. that day—about 45 minutes before the earthquake—something they did not normally do. This is analyzed in Chapter 5, Section 5.8.

(c) Birds (281; 35 %) at the epicenter

Crows (102; 13%) flocked to a bamboo cluster at midnight, cawed loudly and restlessly (in keeping with the old proverb of noisy crows inviting disaster), and moved out to the suburbs (away from the epicenter).

Cocks crowed from 2 a.m. on January 17 in Okayama, 100 km from the epicenter.

Eggs: All eggs in a clutch laid before the earthquake had two yolks.

Seagulls disappeared from the epicenter and flew inland two days before the quake.

Sparrows (33 reports) disappeared from the epicenter before the earthquake.

Pigeons were seen rising in startled flight at 1 p.m., a day before.

Parrots normally talking frequently, fell silent and some showed signs of panic.

Pheasants screamed at 2 a.m. on Jan. 17 and again a few minutes before the quake.

Peacocks cried continuously for two days before the quake.

Parakeets flew round a cage in panic and one attacked another the day before the quake, but behaved normally again after the quake.

(d) Reptiles and insects (43 and 40 reports; 6 and 5 % of reports on animals)

Crocodiles clawed violently at the glass walls of their enclosure in the Kobe-Oji Zoo on the night of January 16, leaving scratches on the glass.

Snakes: A snake came out of its hole at a site 30 km away from the epicenter—an unusual event in winter.

Turtles woke prematurely from hibernation and attempted to climb the wall of an aquarium.

Stag beetles sleeping in wood chips woke up and emerged.

(e) Fish (93; 5 %)

A day before the earthquake, innumerable fish in a pond in Nishinomiya city, floated motionless near the surface, oriented east-west. Some fish were floating high or captured in great numbers, and others did not appear at all at various angling spots at the nearby beach. Some fish normally inhabiting surface water at the Osaka Marine Aquarium sank to the bottom and stayed motionless.

Deep-sea fish: *Regalecus*—popularly called the earthquake fish—normally frequenting deep water, was captured near the surface (Figure 2.4).

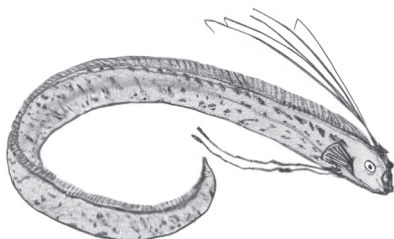


Figure 2.4 A drawing of the deep-sea fish, *Regalecus*, legendarily called the earthquake fish, a messenger from the dragon king's palace. This fish, up to 4-5 meters in length, is known to come up to the surface before earthquakes.

Catfish, loaches, flounder leaped violently out of their aquaria up to 2-3 days before the quake and again at 0:30 a.m. on January 17.

Dolphins at the Suma Aquarium, near the epicenter, moved nervously and leaped onto land a day before the earthquake.

Octopus: Many crammed into one trap. Some were found on shore moving with a staggering gait.

Squid: Local fishermen prophesied there would be an earthquake because of the large catch of squid in the month of December.

Fresh-water fish: Fish kept in a flowing water channel leapt out of water at the Aquapia facility about 60 km away from the epicenter and close to the Arima-Takatsuki tectonic line adjacent to the Nojima Fault. Numbers of fish behaving this way increased to nine in the period January 1 to 17, 1995, compared with two or three per month after the facility's opening in July, 1994. Species living near the bottom also leaped out, which puzzled the keepers.

(f) Plants (11; 1 %) swung in still air and flowered early.

Orchid: There were reports of a subtle swinging of orchid flowers and fluttering of leaves in windless conditions before the quake, and also of early flowering and re-flowering of some plants.

2.2.4 Unusual behavior of electric appliances—the “Alice in Wonderland” syndrome?

One new but characteristic feature was reporting of malfunctioning domestic electric appliances before the quake, presumably from electromagnetic interference. This was also evidenced in increased complaints from TV viewers: Japanese are demanding viewers, frequently registering complaints about noise on their TV screens from natural transmission disturbances caused by the appearance of sporadic E layers in the ionosphere in July.)

(a) Spontaneous on-and-off switching of electric appliances, and mysterious sounds

Fluorescent lamps: There were reports of lamps lighting dimly before the Kobe quake (as during earthquakes) and of mysterious buzzer and alarm sounds from intercoms and cellular phones.

Spontaneous switching on: Many people were surprised and puzzled when radios, TV’s, and one cooler (though this was winter) turned themselves on from a few hours to a few days before the earthquake, sometimes around midnight or 2 a.m.

Strange sounds: Odd noises were reported from refrigerators and yogurt spoiled (possibly from spontaneous switching on and off of refrigerators).

(b) Noises on TV and radio and channel-setting anomalies

Some TV screens normally showing no speckle or flicker or electronic noise showed noise, “barber pole” color, distortion of the screen image, line noise and white bands before the earthquake (See front color plates and Chapter 9, Figure 9.3). Color screens turned black and white with image distortion; these were recorded on videotape. Remote controls worked erratically and TV sets fluctuated between channels, but worked normally again after the quake.

Truck drivers on highways near the epicenter could not pick up radio transmissions around 5 a.m., 45 minutes before the earthquake. (Professor Yoshino who first discovered electromagnetic (EM) signals before earthquakes (Gokberg *et al.*, 1982) traced this story.) Radio wave interference jammed broadcast radio waves along the fault line.

(c) Rapidly rotating clock hands

Quartz clocks showed fast or delayed times. One radio clock in Osaka (near Kobe) which normally readjusted automatically to GMT signals received by radio wave at 100 kHz every hour, was running two seconds slow before the earthquake, but functioned normally afterwards. Few will believe a similar and surprising report that the second hand of a quartz clock began to rotate quickly, first in one direction then in the other, a day before the earthquake.

Are these reported phenomena facts or invention? Can science explain them? Reproduction and simulation experiments on malfunctioning home electric appliances are described in Chapter 7.

2.3 Unusual phenomena before the Izmit Earthquake (M7.4) in Turkey

2.3.1 The Izmit Earthquake in 1999 and field survey

The Izmit Earthquake (M7.4) at 3:02 a.m., August 17, 1999, destroyed Izmit and Adapazari (See Figure 2.5), on the North Anatolian fault, one of the world's longest and most active strike-slip (horizontal motion) faults. The 1999 event is the 11th quake of $M > 6.7$ since records were first kept. Local soil conditions under buildings also affected the degree of shaking and ground failures. Dr U. Ulusoy (1999), who returned to Turkey after eight months in our laboratory as a post-doctoral fellow studying Electron Spin Resonance (ESR) of geological fault materials, asked citizens to report anything unusual they noticed before the earthquake. She collected 880 statements by 348 witnesses (male: 198, female: 150) by letter (105), fax (114), email (86) and phone (43). However, there were few reports from the epicenter area. So we visited the epicenter areas, Adapazari and Izmit one month after the earthquake and collected 137 statements directly from witnesses then living in tents and nearby villages. These proved to be very similar to reports from



Figure 2.5 Land subsidence and destruction caused by the Izmit Earthquake.

Kobe, and are classified in Figure 2.6. Scientists in Turkey seemed skeptical of the reports and critical of the publication, *Earthquake Precursor Data and Scientific Interpretation* (Ulusoy and Ikeya, 2001).

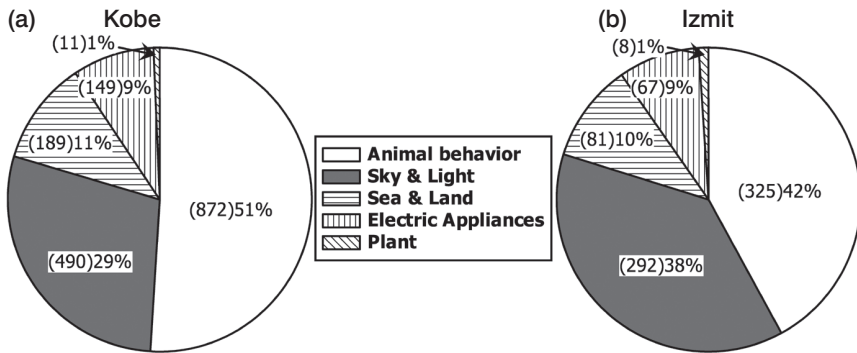


Figure 2.6 Comparison of precursor phenomena from (a) the Kobe Earthquake (Wadatsumi, 1995) and (b) the Izmit Earthquake (Ulusoy and Ikeya 2004).

2.3.2 Unusual atmosphere and sky

(a) Earthquake light (EQL) (208 reports:)

Many reported seeing light at the time of the earthquake. The color of the light was white and blue; sometimes reported as green at Izmit and red at Adapazari, 40 km away from the epicenter. Japanese NHK TV broadcast a documentary on the Turkish earthquake in which a scene at a gas station showed EQL at the epicenter. Some coseismic lightning in a big city might come from shorting of electric power lines during the shaking, but many reported seeing the light before the arrival of seismic S-waves or surface L-waves (produced by torsional oscillation).

For several days after the quake balloons of bright light came out of the sea over the Gulf of Izmit and the northeastern Marmara Sea and sounds of explosions were heard from the gulf area (Barka, 1999). Fire balls (presumably ball lightning) were observed several times during a period of two or three months before the earthquake, according to a fisherman (Ulusoy and Ikeya, 2002). Some fishermen described a co-seismic undersea explosion and light ascending out of the water into the sky. Fishing nets were found burned.

(b) Clouds and fogs

There were reports of striped clouds (contrails), black-gray fog and reddish-pink or orange skies. White fog was covering a graveyard when people left buildings at the time of the quake.

(c) Stars and moon

Stars: seemed unusually bright and extraordinarily close to the earth before the earthquake and also before the big aftershocks. Some seemed to move like comets with tails.

Moon: appeared to be reddish and vertically elongated.

2.3.3 Unusual animal behavior

(a) Mammals (291; 23 %)

Reports of unusual animal behavior before the Kobe and Izmit earthquakes are summarized for different species in Figure 2.7.

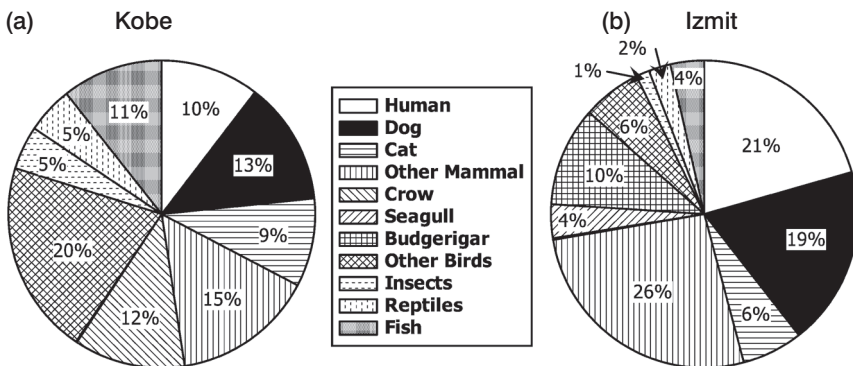


Figure 2.7 Animals showing unusual behavior before (a) the Kobe Earthquake and (b) the Izmit Earthquake (Ikeya and Ulusoy, 2000).

Dogs and wolves (106): Wolves (*Canis lupus*) howled mournfully for one and half hours before the Izmit Earthquake on August 17. They barked briefly 15 minutes before the M5.8 aftershock at 3 p.m. on September 13, the day the author arrived there. Dogs howled insufferably, as if they had rabies, or mournfully like wolves, barked loudly, or whined anxiously or panicked. Some barked and pulled their owners out of the house, others refused to eat, sought human company, ran off and then returned, or ran to the cover of trees in the park. They aggressively attacked other dogs, bit their owners, disappeared, formed packs and acted as if they were hunting an unseen enemy. They dug furiously at the ground, cocked their ears to the ground, looked up at the sky, and stood on their hind legs.

Cats (36) left home or disappeared for days before the earthquake. Some became restless, meowed unhappily, took kittens outside, climbed a high tree or wooden

furniture, lay on their stomachs, or, legs splayed, moved in a cringing fashion; climbed their owner's backs or bodies, insisted on protective holding by owners, panicked, bit their owners, and refused food.

Horses snorted, left their owner's farms, stamped the ground and jumped skittishly around.

Cows bellowed, crowded together, aligned themselves in one direction, refused to return to farms from mountain areas, were aggressive towards owners during milking, or seemed unusually happy to be near their owners.

Sheep seemed troubled as they grazed, bleating uneasily and crowding together.

Bats flew restlessly in circles.

(b) Human beings (116; 25 %)

People reported lost appetite, exhaustion, nausea, diarrhea, dizziness, nervous disorders, hysteria, facial ticks, high blood pressure, bleeding noses, headaches, cold feelings, pains in knees, bad weather symptoms, heart complaints and frightening dreams. There were reports of sensations of electric current in the brain or from finger to elbow, of an unusual amount of yawning and of disturbed menstruation.

A pregnant mother reported the movement of her baby in the womb suddenly stopped a few minutes before the earthquake.

Children woke and cried: The manager of a Toyota Car franchise in Adapazari said his son, a four year-old boy, woke his parents frightened that something was about to happen. His wife remarked that she had heard dogs howling like wolves. Five minutes later, the earthquake occurred.

Another Adapazari woman said her daughter of one and half years woke her up 15 minutes before the quake. She changed her clothing and both were awake and able to flee their home when the earthquake struck. A spastic child cried before the quake and laughed afterwards.

Most of the reports echoed the Japanese proverbs and stories collected after the Kobe Earthquake. Turkish interviewees were not aware of human symptoms before earthquakes. They were not aware of the Kobe reports before or during the survey.

(c) Birds (115; 25 %)

There were reports of unusual behavior on the day of the earthquake and the day before.

Budgerigars and parakeets (59) twittered in high tones, fluttered and woke up at 2 a.m., one hour before the earthquake. They kept to metal parts of the cage (contact with metal minimizes uncomfortable voltages) and did not go near their

wooden perches. They shrieked, flew or walked at night, refused to eat or sing. For some reason such budgerigar reports were abundant in Turkey.

Tropical yellow parrots: These birds, similar to budgerigars, shrieked and panicked at the Darica-Kocaeli Bosphorus Zoo. Some experiments on these parrots are described in Chapter 4.

Seagulls (20) flew inland, flew restlessly about the sky crying, and flocked to roofs of buildings.

Crows stopped cawing, or gave weird calls, dived to windows and metal parts of cars and flocked to car roofs, although these were very hot.

Swallows twittered eerily, chirped “as if to warn their mates”, flew restlessly round in circles, dived to walls of buildings but only on an east-west axis and attempted to find footholds on the wall.

Storks flew round in circles, then restlessly and prematurely migrated.

Cocks crowed at midnight, flapped their wings, panicked and shrieked.

Geese panicked, gobbled—as if in terror—and flapped their wings.

(d) Reptiles (13; 2.8 %)



Figure 2.8 These crocodiles at the Darica-Kocaeli Bosphorus Zoo, refused to enter their pool after the Izmit Earthquake. Though keepers were not observing their behavior before the earthquake it is possible the animals experienced the pool as an uncomfortable environment before the earthquake and were reluctant to re-enter it afterwards (Chapter 4).

Crocodiles at the Darica-Kocaeli Bosphorus Zoo (Figure 2.8) refused to enter their pool.

Lizards entered a house in unusual numbers.

Snakes swarmed in a garden.

Frogs stopped croaking and clung to the outside upstairs window of a house.

(e) Fish in the Gulf of Izmit (20; 4 %)

Fish and crabs: Starting two days before the quake, hundreds of fish, crabs and other living animals died. Visible fish numbers increased and some were seen in

a state of panic. Fish lost their normal fear of humans, and floated vertically with their mouths open.

Deep-sea fish were seen swimming at the surface a day before the earthquake.

Crabs: Large numbers of crabs were found dead two days before the earthquake (Barka, 1999). Many crabs left their wet habitats, crawled ashore and were found in large numbers at a house 60 m inland. Some swam in the sea rather than remaining on the seafloor; the same behavior is described in Japanese literature.

Freshwater gastropods appeared at the seaside.

Jellyfish appeared two days before the earthquake (Barka, 1999) and also afterwards.

(f) Insects and worms

Ants: Left their nests, climbed trees and entered houses.

Bees aggressively stung humans and buzzed people to an unusual degree.

Cockroaches clung to upstairs window frames and hid close to metal ware.

Earthworms came out of the soil and even climbed to an upstairs floor.

Flies disappeared, bit aggressively, clung to human bodies and rotated as they did so.

Cicadas stopped chirping before the earthquake.

Mosquitoes either disappeared or greatly increased in number after the quake.

(g) Plants (23; 3%)

Plants dried up and leaves wrinkled. Plants grew slowly.

Reported animal and plant behaviors before the Izmit Earthquake are similar to those reported in Japan although most Turkish people were not aware of such phenomena. Some phenomena suggest clues to the nature of the physical disturbance sensed by animals and plants.

2.3.4 Unusual phenomena on land and sea (92; 10 % of total)

Land movement: People noticed higher sea levels, seaweed and mud deposits at the shoreline before the earthquake.

Wave sounds like the waves of the sea were heard underground near the seaside.

Death waves: Sudden and unexpected ocean waves splashed the shore areas. (The local people call these “death waves” because of their popular association with earthquakes.)

Monotonous weather (29): Very high temperature and humidity, with no rain, no wind; “boring” weather. People felt the effects of the sun more than usual.

Elevated water temperatures: Seawater, well water, hot spring water and ground water were unusually high in temperature.

Odor: People reported smells like sewage or burnt cables, both before and after the quake.

2.3.5 Malfunctioning electrical appliances (63; 7 %)

Reports of malfunctioning home electric appliances before the Izmit Earthquake comprised about 10% of total reports, similar to Kobe.

TV and radio (20): Radio noise and TV flicker and visual noise were reported as worse than usual before the quake.

Clocks (7): Three quartz clocks in different rooms, which normally showed identical times showed different times: fast, slow and normal before the earthquake. Afterwards people reset the clocks and they again synchronized perfectly. Another report claimed the second hand of a clock stopped.

Midnight Prayer: An unscheduled highly amplified Koranic prayer from a loudspeaker surprised people at about 2 a.m., one hour before the earthquake, possibly because a broadcasting device spontaneously switched on.

Phones and others (36): A man was woken at midnight by the ringing of his phone, but no one was on the line. The phone rang again and a few minutes later the earthquake occurred. He was unable to find anyone among his friends or relatives who had called him at that hour. Other reports about phones describe indicator lights on mobile phones lighting up and the phone ringing but no record of calls.

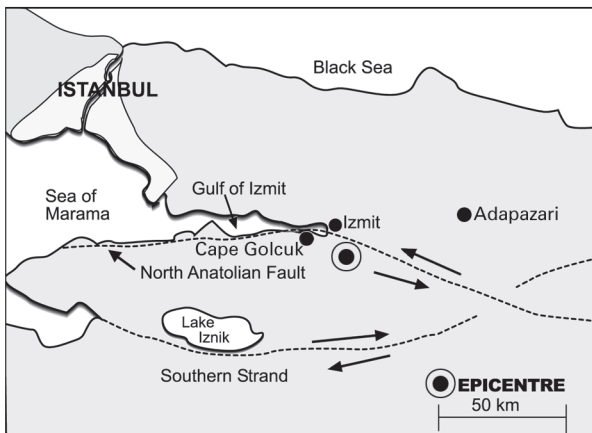


Figure 2.9 A map of the Gulf of Izmit, Turkey, indicating Cape Golcuk, the North Anatolian Fault and cities where the surveys were undertaken.

Powered car window: A car window opened and then changed its direction of motion. A refrigerator and washing machine more than 300 km from the epicenter made strange sounds.

2.3.6 “The Moses Phenomenon” (1; 0.1 %)

A strange incident was reported in which the sea parted near Cape Golcuk in the Gulf of

Izmit and a boat touched the sea floor (See Figure 2.9). This was the only statement that differed from Japanese precursor reports. As the fisherman himself put it:

I heard strange sounds and felt vibration at 2.57 a.m. There was something strange about the sounds of the screw and the vibration of the boat. I checked the screw, but there seemed to be no problem. Then I saw pinky-red color light streak from the sea surface into the sky. At about 3.04 a.m. the sea suddenly split in two and my boat went down and touched the sea floor. I saw walls of water on both sides of the boat, and then big waves bore me towards the Turkish Naval School buildings and I was carried to land.

The statement has interesting echoes of the Biblical account of the crossing of the Red Sea (Exodus 14:21) but could be explained by the local geography there as calculated theoretically and demonstrated in a model experiment in Chapter 8.

2.4 Precursors of the Taiwan-921 Earthquake (M7.7)

2.4.1 The Taiwan-921 Earthquake and field survey

The disastrous Taiwan-921 Earthquake (M7.7) struck the central part of Taiwan at 1:47 a.m. September 21, 1999, killing more than 2400 people. The epicenter was near the town of Chichi, Nantou County, along the Chehlungpu fault. (The earthquake was later renamed at the request of the Chichi townspeople.) Large-scale landslides and solid-soil liquefactions occurred, severely disrupting transportation, power and communication lines (See Figure 2.10).

The author visited Taiwan to collect precursor reports and collect samples of fault gouge from the surface fault ruptures for ESR analysis.

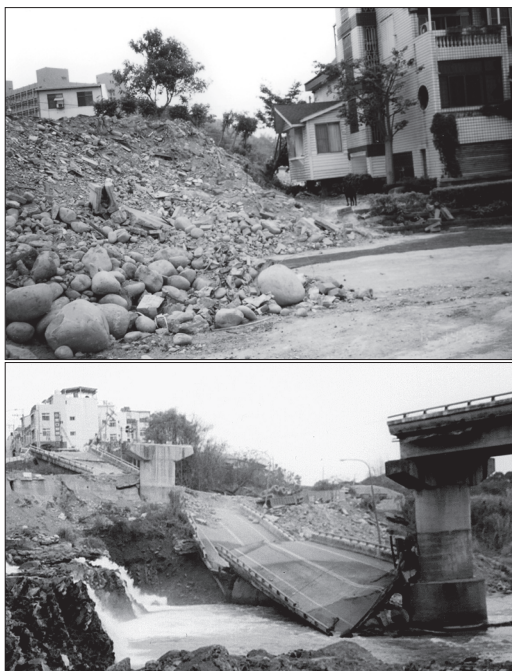


Figure 2.10 Outcrops of the Chehlungpu Fault that moved at the time of the Taiwan-921 Earthquake.

Dr D. T. Shih at the Geological Survey of Taiwan helped us collect reports recorded in this section (Ikeya *et al.*, 2000). Wadatsumi visited Taiwan immediately after the quake and collected stories through mass media advertising. In the following, the number of cases and percentages in parentheses are from Wadatsumi's home page (<http://pisco.ouss.ac.jp>).

2.4.2 Unusual atmosphere (320; 11 %), water (229; 8 %) and land (227; 8%)

A certain well showed an unexpectedly high water level of 4.0 - 5.7 m before the earthquake, but decreased considerably afterwards. Water became turbid three weeks before the quake and clear again three days afterwards. The same pattern was observed before the M6.5 aftershock a week later and the M6.8 earthquake one month later.

There were reports of ground to sky lightning, and low frequency sounds from the ground, before the tremor, which created a wave half a meter high in a lake.

2.4.3 Unusual behavior of animals, plants and electric appliances

(a) Mammals (623; 23 %) and birds (142; 5 %) in Taiwan

Dog: A dog howled repeatedly like a wolf—a frightening omen in Taiwan. The owners could not quieten the dog, which broke its chain before the quake and escaped. Its quarters were destroyed in the quake.

Dog hiding in an iron pipe: A mother dog with her three pups crawled into an iron pipe before the Taiwan-921 and would not come out. People thought the dog considered the pipe a safe haven. (Cockroaches and crows also sought out metal before the Izmit Earthquake.)

Cat: A cat which had made its home in a garage at the north edge of the Che-lungpu fault, moved out. A few days later, the quake destroyed the garage.

Monkeys: A large number of monkeys came out of mountains two weeks before the quake, screamed and shook trees just before the quake, and returned to the mountains three hours afterwards.

Panicked chickens: The Japanese newspaper, *Nikkei*, on September 24, 1999, carried a story that one and half million chickens in a chicken farm in a suburb of Shanghai city, about 1000 km from the ocean epicenter, panicked and attempted to flee their cages before the Taiwan-921 Earthquake. Two hundred thousand chickens were injured; twenty thousand died. Is it possible that even though they were so far away they still picked up some earthquake precursory signal?

(b) Fish (165; 6 %), reptiles (178; 6 %), insects (433; 15 %) and others

Fish: Anglers caught many fish during the night of the earthquake until they suddenly stopped showing interest in the bait and began leaping from the water.

Carp in a pond died from knocking their heads against the pond barrier.

Deep-sea fish: The Ribbonfish (Jordan & Snyder, 1901), with large eyes, no teeth and a red colored back is rarely caught, but a fisherman caught one month before the quake. One of the same species was also caught before a large earthquake in 2002.

Snakes formed swarms and were easily captured and cooked by local people.

Ants: A day before the quake ants near the fault were observed carrying their eggs to another habitat.

Earthworms: A large number of earthworms appeared above ground all over Taiwan before the main shock. Another swarm of earthworms surfaced on October 25, eight days before a big aftershock (M6.9) on November 2 (Figure 2.11). Chapter 4 describes an experiment on the site.

(c) Plant anomalies (24; 1%): Burnt plants and peculiar plant movements.

Plants: Plants with burned roots were observed at the northern edge of the fault.

Brown-colored tips: Blades of grass were found to be brown at the tips close to the fissure.

Upward pointing leaves: The leaves on a tree in an artist's garden at the north edge of the Cheilungpu fault pointed upwards before the quake when normally they hung earthwards. A warm current of air streamed from the ground to the sky in the garden where usually the air movements were cool. Grasses in the garden were brown at the tips. These plant behaviors were reproduced in experiments as described in Chapter 6.

(d) Electric appliances (124; 4%):

A policeman noticed rapid movement of the hands of his clock before the earthquake (but still managed to be late for his date with his girlfriend, according to the report).



Figure 2.11 Earthworms emerged on the surface in large numbers in Taiwan just before the main quake and again some days before a large aftershock, when this photo was taken. (Photo: Mr Chen, Kaoshung Elementary School).

2.5 The West Indian (Gujarat) Earthquake (M7.7) in 2001

2.5.1 Field survey and newspaper reports: EQL and sounds

There were many reports in local newspapers of unusual animal behavior before this earthquake (M7.7) in the Kutch region, Bhuj, Gujarat at 8:46 a.m. on January 26, 2001 (Kusala *et al.*, 2001), but little academic attention was paid to them.

Dr H. K. Kundu, Geological Survey of India, Calcutta, visited the area and collected firsthand most of the following reports of unusual phenomena.

EQL: Dr M. Thakkar, Lecturer in Geology, R. R. Lalan College, Bhuj, was staying on the fifth floor of an apartment house. At the time of the earthquake, he made his way to the ground with his wife and two year old daughter. Just as the earthquake ended, he noticed the eastern sky was pale yellow in color. The color gradually faded and the sky resumed its normal blue-ash color.

Mrs M. Joshi was outside her house at the time of the earthquake and felt nauseous as her house and those about it began to swing. She remembers looking at the eastern sky and noticing it looked yellowish and reddish-yellow for a few seconds.

Sounds: The Internet posted the account of a man who predicted the earthquake on January 24 after he heard sounds emanating from the earth: a humming echo followed by rumbling sounds like heavy vehicles or falling objects, then sounds like thunder.

2.5.2 Unusual behavior of animals and plants

Dogs in a village called Baniyari, 53 km from Bhuj, barked loudly through the night of the quake (January 25-26) until the sun rose. The barking alarmed many people, but they did not expect an earthquake. Street dogs that normally ate food offered by villagers would not eat it that night but hid it in small pits and holes. In a TV interview a photographer in Bhuj said his pet dog was restless and barking incessantly two or three days before the quake, its nose constantly to the ground as if it were sniffing out something unusual.

Dogs and cows: The old walled town of Bhuj, about 42 km west of the epicenter near Bandhdi, has become home to many stray dogs and cows. The night before the quake they left the town and only returned to it afterwards.

Cattle: In a village near Dholavira, about 100 km from Bhuj, villagers noticed their cattle became distressed some 10-15 minutes before the earthquake and ran around randomly making “frightful” noises.

Scorpion: Dr A.G. Makwane, Lecturer in Physics, Bahauddin College, Junagarh, Gujarat, was at his agricultural farm in Gondal (50km from Bhuj), three days before the earthquake. He noticed a scorpion coming out of the ground, a very unusual

event in wintertime, and told many people in Gondal and his colleagues in the college that something unusual was going to happen.

Domestic farm animals (cows, buffaloes and horses) refused to eat for three days after the quake.

Elephants: In the Ahmedabad Zoo elephants lowered themselves to the ground just before the earthquake.

Crows: A local taxi driver in the old walled city in Bhuj noticed that the local crow population deserted the roofs of the village one week before the earthquake, but suddenly returned afterwards.

Plants: Dr Thakkar found dried plants along a 9 km line on both sides of the Seer Fault when they visited the area from February 1-14 (Rajendran *et al.*, 2001).

Snakes: In a TV interview, a farmer reported snakes in winter hibernation on his land coming out of their holes one or two days before the earthquake.

2.6 International mail and overall comments

2.6.1 Pigeons, a parrot and cats in the USA: Loma Prieta and Northridge

Pigeons were said to be agitated before the Loma Prieta Earthquake in 1989, leaving their usual roosting areas. Horses at a ranch were unusually skittish. However, scientists considered most of these statements wishful thinking. But after Granada TV broadcast our research on catfish, a former research biologist and avian behavior consultant living in San Francisco sent the author an email describing unusual parrot behavior before the Northridge Earthquake in 1994.

In 1994 there was a M 6.8 quake in Northridge, California—approximately 400 miles south of San Francisco. At approximately 8 pm the night before the earthquake my African gray parrot stared, as if in a trance, at the ground and resisted going into her cage. She hung upside down from perches, staring at the ground. The earthquake occurred at 4 a.m., the next morning. It was not felt in San Francisco. My parrot continued her strange behavior for approximately four hours after the quake. I have since noticed the same behavior for small earthquakes in the San Francisco area, and the intensity of her behavior and its length of time prior to the earthquake depends on the magnitude.... Several months ago there was a large quake in the desert of Southern California. I did a survey of parrots' behaviors just prior to and during the quake. The only bird that did react before the quake was a wild-caught gray parrot. I have an account from a person in Istanbul, Turkey whose African gray parrot demonstrated the same behavior several hours before the first large quake there.. . I also believe that her

behavior is directed only to future quakes on the San Andreas Fault, because we live only a few miles from it. She did not respond to the recent Southern California quake that was on another fault. Regards, Jane Hollander.

Hanging upside down from perches might be an attempt to orient towards an enemy or insects—or towards a signal coming from the ground. Some literature mentions that even well trained police dogs howled, refused to obey commands, and kept their noses close to the ground as if sniffing (Raleigh *et al.*, 1977) apparently supporting such a hypothesis.

Dr Neil Whitehead wrote that a friend in Los Angeles said that his pet dog went “crazy” a few tens of seconds before the Northridge Earthquake, running madly about his house in a way he had never seen it do before.

A Web report on unusual animal behavior in the US says that the number of missing dogs and cats increases significantly up to two weeks before an earthquake and claims that earthquakes can be predicted both by looking at newspaper advertisements of lost pets and checking stresses in rocks caused by lunar gravity. Statistically the latter is still controversial.

2.6.2 Symptoms of a British former POW

The author received the following letter after the BBC program *Tomorrow's World* described experiments on animal behavior and detection of electromagnetic waves during rock compression (see Chapter 5). The incident occurred 60 years ago, just before the Japanese Nankai Earthquake in 1944. His letter reads:

In 1944 I was working on the deck of a partially constructed tug in the Kawasaki shipyard in Kobe. Standing erect and holding a large spanner, I experienced a sudden and nauseating attack of vertigo. I looked at my workmate kneeling on the deck and then around me; everything appeared to be normal.... A bare minute later, the deck began to move beneath my feet, I looked at my pal, his face was green. Amid shouts of “Jishin” (earthquake), all the Japanese working on the Tug scrambled down the ladders to the ground, and we wisely followed. Everyone ran towards the dockyard gates, why? I’ll never know, for the overhead electric cables clashed and splashed, the ships’ hulls rolled from one side to the other and the ground rippled like water. We would no doubt have been safe, finding a clear space. A few months before I finished the manuscript, the recent Kobe Earthquake occurred... my deep, deep sympathy for all the inhabitants who suffered in that catastrophe. Good luck, with your work Professor, maybe some of us humans get early warnings of Terra Firma’s TANTRUMS. Sayonara (Good bye). Arthur Lowe, Lancashire, England.

2.6.3 Overall comments on reports of recent earthquakes: No cultural differences

Turkey is an Islamic country, but close to Christianized Europe and quite different from Japan and Taiwan, which are both influenced by Buddhism. India is a predominantly Hindu country. We expected statements and legends to reflect different religious beliefs. But they did not. The replies of Turkish people to our inquiries about unusual phenomena before the earthquake were very close to those from Japan and China—and most of the Turkish eyewitnesses knew nothing of earthquake precursors. They all described crocodiles, parakeets or budgerigars behaving in similar ways.

Turkish people were puzzled that their electric appliances had malfunctioned and asked us if this could be linked to the earthquake and if so why. Concerned about media exaggeration we replied only that we were collecting people's observations and planned to analyze them later. We gave no details.

Although we took the advice of an industrial psychologist, Professor Kinoshita (Kansai Science Forum), in framing the Turkish survey, the serious involvement of the psychological profession would be valuable in framing and interpreting surveys to eliminate cultural or superstitious bias.

But, so far, because reports are so similar from all earthquake centers, it appears many of the precursor phenomena described are authentic rare natural phenomena.

2.7 Numerical data: fish capture records

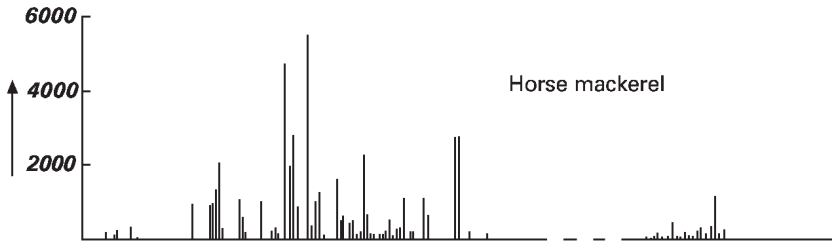
2.7.1 Old work on fishery records by Terada

Skeptics argue that it is impossible to set up an effective objective measure of “unusual” animal behavior but one objective result is given by Professor Torahiko Terada, who checked records of fish catches. Unusual increases of fish catches before the 1923 Izu earthquake swarms were correlated as shown in Figure 2.12. If the figure is enlarged, it can be seen that increased catches preceded the earthquakes by four to eight days. Responding to some signal ahead of earthquakes fish seem to have left their usual habitats and gathered in groups in other areas where they were caught.

2.7.2 Sea bream catches before the Kobe Earthquake

Similar retrospective data just before the Kobe Earthquake in 1995 (Nakajima, 1996) are given in Figure 2.13. A possible precursor time of 6-8 days cannot be distinguished because of a break in record keeping over the New Year holidays, but the increase both before and after the earthquake is clear, as seen in (a). It is

Fish Capture (number)



Earthquake (frequency)

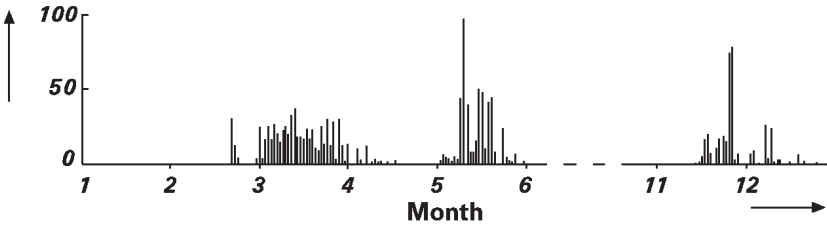


Figure 2.12 Fishing catches as a function of time before the Izu earthquake in 1923 and various seismic events (Terada, 1932). Although Terada made no note of it, the precursor times seem to be around a week.

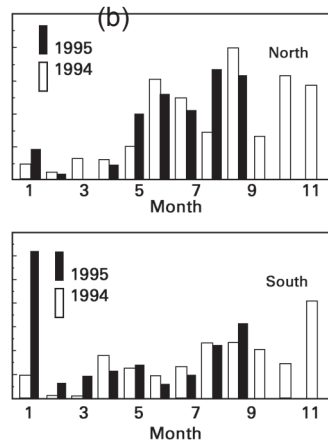
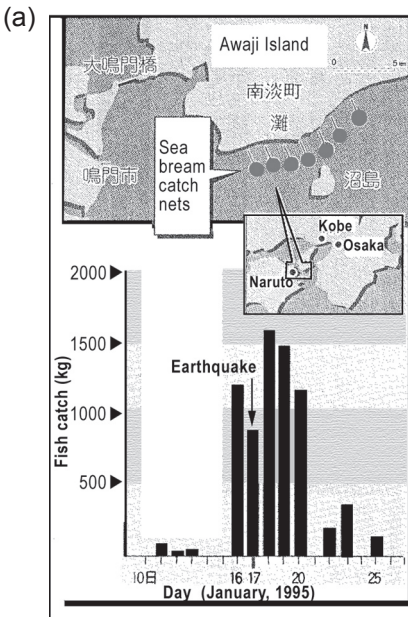


Figure 2.13 (a) Fishing catches as a function of days in January, 1995, in relation to the Kobe Earthquake (Nakajima, 1996, as reported in the *Sankei* newspaper). (b) The monthly catch of fish in 1994 and 1995 at northern (upper figure) and southern (lower figure) Awaji Island.

plausible that fish moved from the epicenter on the northern part of Awaji Island to the southern part where they were captured, as seen in (b). The data clearly indicate an unusual increase in fish capture; no such increase showing up anywhere in the remaining 10 year record. Daily records of buying and selling of fish were unfortunately discarded and only monthly totals were kept at the Osaka Central Fish Market.

2.7.3 Fishery records at the Istanbul market

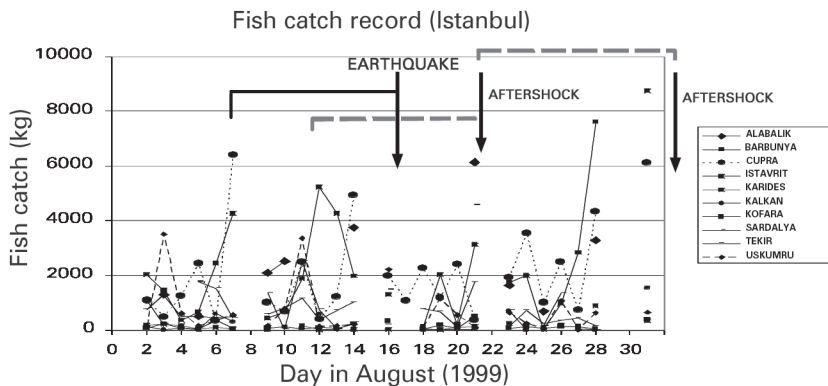


Figure 2.14 Fish catch records at the Istanbul Fish Market before the Izmit earthquake (M7.5), Turkey. The Izmit Earthquake occurred 9 days after the big catch. Following peaks might be either the precursors of large aftershocks or the consequence of microfractures of fault segments which also moved at the time of the mainshock (Ulusoy and Ikeya, 2001).

Because the epicenter of the Izmit Earthquake extended into the Gulf of Izmit we decided to get access to daily fish catch records at the Central Fish Market in Istanbul—according to species. The daily variations in August, 1999 are shown in Figure 2.14 and compared with seismic events.

Unusually, a deep-sea fish, called Kofara, appeared at the market only three to four days before the 1999 Izmit Earthquake in Turkey. We are not sure how the fishing records should be correlated with the earthquakes but the data are capable of an interpretation consistent with Terada's big catches 4-8 days before the main shock.

The Izmit Earthquake was the result of a few major ruptures triggered by fault movement. Each preseismic microfracture might have given signals leading fish to relocate and gather elsewhere—near a fishing ground—leading to a peak catch. Thus, the first peak catch may be eight days before the main shock and the two

subsequent peaks may be associated with one of the big aftershocks. Some peaks might even be related to the later earthquake of November 2 (M7.2), though that earthquake was inland, while the Izmit Earthquake was close to the bay.

2.7.4 Comments on fish catch records

One remark should be made about precursory times. It could take a full day for fish to find their way to markets. The distance between the epicenter area and the catch site is also a factor. This makes the precursory times in Terada's work roughly concordant with times of other phenomena mentioned elsewhere in this book.

Sardines have also been captured in increased numbers before earthquakes, and deep-sea plankton have been found in their stomachs, indicating their movement close to the surface of the sea (Suehiro, 1976).

These studies suggest that fish catches might be useful in seismic prediction, but with qualifiers. Obviously fish capture depends on tidal flow, weather, and huge climate determinants like El Nino, etc.; larger than normal fish catches clearly cannot simply be attributed only to impending quakes. But if seasonal fish capture data for earlier years are studied for comparison, apparent increases may turn out to be identifiable earthquake precursors.

These difficulties in interpretation may be the reason why Terada's research was discontinued in Japan. But such fish catches could be monitored in real time, or records retrieved immediately after big earthquakes, for analysis for relationship to earthquakes.

2.8 Space and time distribution of precursors

2.8.1 Are unusual phenomena just wishful thinking?

We often encountered the following sort of objections.

There are hundreds of dogs in the epicenter and surrounding areas. Dogs bark all the time for all sorts of reasons—they might have fleas in their ears—and if they happen to bark the night before an earthquake that's nothing out of the ordinary. People feel tired and headachy all the time. Since there are millions of dogs and people, there are bound to be a number of such reports before earthquakes.

Or

Witnesses who have been alarmed or traumatized by an earthquake will connect everything with it. They will turn any trivial incident that happened before it into a precursor. If there had been no earthquake, they would never have remembered it. This tendency will decrease the further you get from the epicenter because the tremor also decreases.

On the face of it these seem reasonable objections, but there is sufficient time and location dependence of different kinds of phenomena that a correlation is clear. In other words the precursor reports are not completely random or invented. Statistical evaluation shows a significant correlation (See comments on chi-squared tests on the next page, and in Sections 5.8 and 7.6.2).

On dogs, specifically, veterinarians remarked that 20% to 30% of clients before the Kobe Earthquake who either called to seek advice about the odd behavior of their animals or brought animals in for care, said that they were behaving in unusual ways. This, compared with a normal zero level. The trend was sufficiently pronounced that two veterinarian co-workers, Drs M. Ohta and M. Hatoya, have collected blood from these dogs for genetic analysis to see if it might be possible to breed a species of “earthquake watchdog”.

2.8.2 Spatial distribution of precursor phenomena

Animal species, distance from epicenter, and time before the main shock were plotted to see whether there were any correlations (Yamamoto *et al.*, 1999, Figure 2.15). A trend is visible: small birds appear to respond before larger mammals. A chi-squared statistical test on this figure shows the chance of these reports being sheerly random is vanishingly small (less than one in a trillion). The trend is therefore real; if it were only psychological the ratio of reports should have stayed constant.

Figure 2.16 shows phenomena reported at various distances from the Kobe

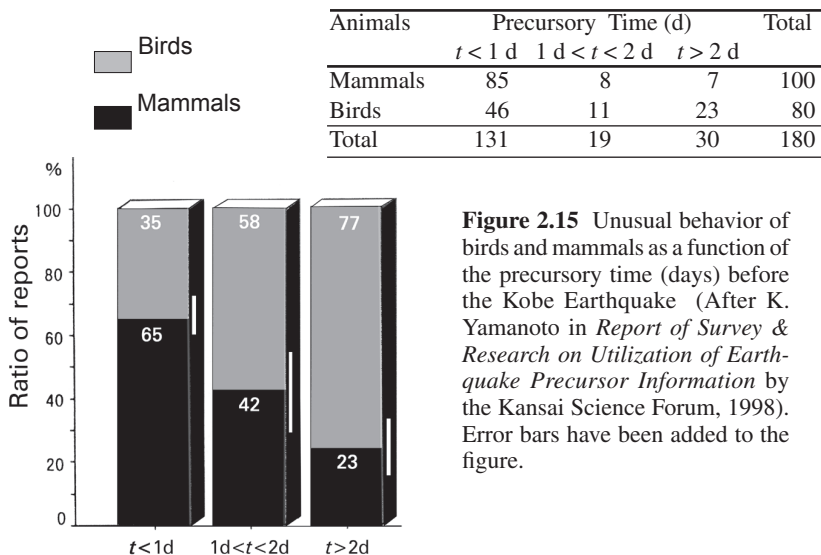


Figure 2.15 Unusual behavior of birds and mammals as a function of the precursory time (days) before the Kobe Earthquake (After K. Yamamoto in *Report of Survey & Research on Utilization of Earthquake Precursor Information* by the Kansai Science Forum, 1998). Error bars have been added to the figure.

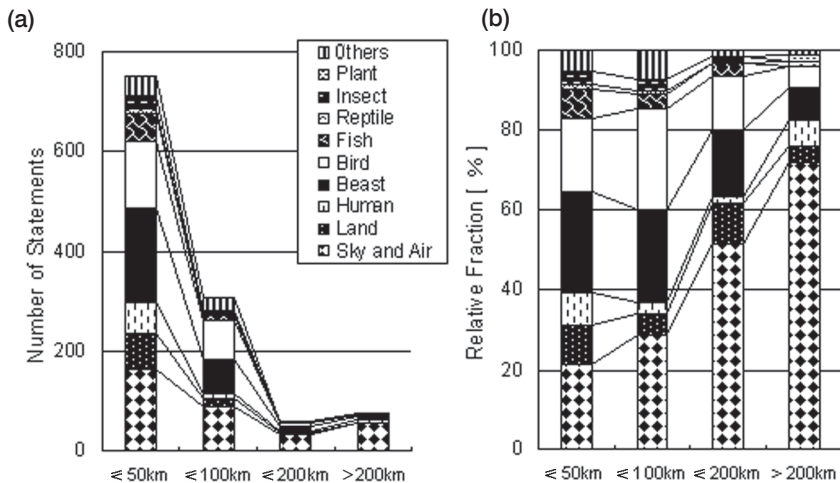


Figure 2.16 (a) Numbers of reports of unusual phenomena before the Kobe Earthquake, in relation to distance from the epicenter. (b) Their relative ratios normalized to 100. (Data taken from Wadatsumi, 1995.)

epicenter. Reports of unusual bird activity increase just outside the epicenter area, then drop the further the distance from the epicenter, while reports of unusual sky phenomena increase according to distance from the epicenter. Possibly birds migrated away from the epicenter areas before the quake but the sky phenomena were mainly observable from long distances. There is more information on time and location dependence of precursor appearance of sun, moon and clouds in Chapter 7. For data on location-dependent and time-dependent human responses, see Chapter 5, Section 5.8.

2.8.3 A speculative mechanism for temporal shift of unusual behavior from small to large animals

The Chinese have observed that small animals show unusual behavior first and large animals later and closer to the main shock; this was observed particularly before the Haicheng Earthquake (Raleigh *et al.*, 1978). Rikitake (1978) noted that small animals like insects showed unusual behavior first and then larger animals e.g. rats, birds, cats, dogs, pigs and horses up to one hour before an earthquake. The animal size effect as shown in Figure 2.17 might be explained as an EM absorption effect [See Chapter 3, Figure 3.17 (b)]. Fracturing of small crystal grains in rock may lead to generation of sharp, seismic EM pulses with more high frequency components and a small pulse width, to which smaller animals are more sensitive.

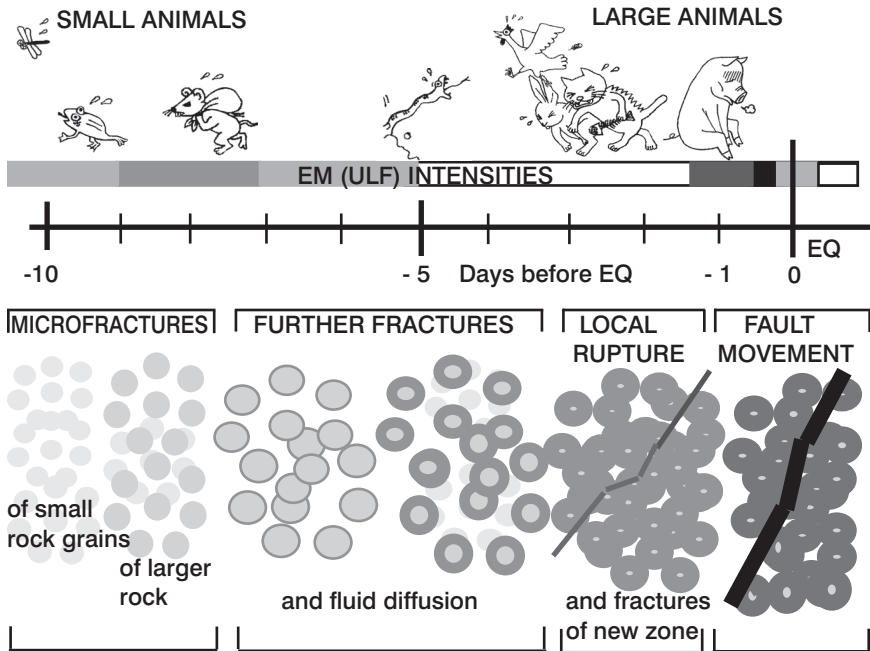


Figure 2.17 Showing the shift from smaller to larger animals over time, together with EM intensities (in gradients of black), and stages of rock fracture over the same period (with increasing fluid diffusion shown at the circle circumferences).

Only at a later stage when pressure is building up and larger rocks are fracturing will broader pulses with lower frequency components be generated to which larger animals and humans are more sensitive. [There is more on microfracturing and creation of EM waves in Chapter 3 (3.2.4, 3.3.7, 3.3.8).]

However this is speculation. Only in exceptional cases may higher frequencies reach the surface (up a moist, rarely occurring conductive path). The much more likely scenario is that only ULF waves of similarly decreasing frequencies have a large enough skin depth (See Section 3.3.4.) to reach the surface. There they generate intense electric fields whose local discharges produce EM waves with high but decreasing frequencies, which are the waves directly responsible for the animal precursory behavior.

2.8.4 Times of precursor phenomena before earthquakes

The precise times of observation of precursor phenomena are hard to pin down since the reports are made retrospectively. However a theoretical formula has been proposed using Rikitake's empirical data for species-specific animal behavior for a certain magnitude (M) and distance from the epicenter (Ikeya *et al.*, 2001). Fraser-

Smith *et al.*, (1990) proposed two peaks in precursor time for seismic EM waves at ultra low frequency (See Chapter 11, Section 11.3.1. and Figures 10.2 and 11.4).

Peak I: For frequent M7 earthquakes: from about two weeks before, peaking at 7 to 12 days before, and then decreasing.

Peak II: For M7 earthquakes: One or two hours before.

2.9 Summary

Reports of precursor phenomena gathered after four recent large earthquakes back up earthquake proverbs, legends and folklore abundant in the East, and these reports are tabulated in Tables 2.1 to 2.4 for the interest of readers. Whether these are genuine earthquake precursory phenomena or psychological in nature will always be controversial. However data showing time and location dependence of animal responses before earthquakes indicate that the reports have a more than merely psychological or superstitious basis.

In 1933 Terada wrote an essay entitled *A Group of Animals Regarded as a Group of Materials*. At the end of his article, he added this:

These studies are always regarded as heresy based on the conviction that physicists do not understand biology. What hinders the progress of science is not the ignorance of lay citizens but the lack of recognition of the essence and mission of science by scientists themselves. We must think deeply about this.

Nothing has changed much in the last 70 years. One can talk about physicists instead of biologists, or biology instead of geophysics or seismology. Many physicists, geophysicists, biologists and seismologists are alike in their tendency to confine themselves to their sub-fields when science in the 21st century demands a much more unified approach.

Table 2.1 Unusual animal behavior before earthquakes

Mammals	Nervous, restless, irritated, panic and act “crazy”.
Human	Headache, nausea, urge to vomit, giddiness, dizziness, heart complaints, nervous disorders, hysteria, bad weather symptoms.
Dogs	Bark loudly, whine a lot, anxious. Act as if tracking an unseen enemy; panic and bite owners, bark and pull owners outside, howl endlessly.
Cats	Restless, meow pathetically, take kittens outside, climb high trees, twitch ears, lay ears back, leave home for days, disappear.
Rats	Disappear, fuss, panic, run along wires.
Horses	Stamp, snort, tremble, jump, buck, fall to the ground.
Cows	Bellow, crowd together, run away in panic.
Pigs	Aggressively bite each other, dig under fences, attempt to climb walls.
Deer	Leave bush and forest, do not fear humans, run to humans, run aimlessly.
Rabbits	Jump and run around.
Sea lions	Swim in zigzags, act agitatedly, fuss when out of the water, do not eat food.
Dolphins	Nervous, do not obey orders, leap out of the water.
Bats	Fly in the daytime.
Birds	Stop singing, become excited, flock restlessly, cry weirdly, some die.
Chickens	Flap wings, shriek as if in terror, fly, fly to roofs. Cocks crow at midnight.
Hens	Lay no eggs, or fewer eggs.
Ducks	Avoid entering water, cry, act aggressively, bite humans.
Sparrows	Flutter in swarms, flutter down while flying, no twittering.
Seagulls	Fly inland, mew in sky, stay away from the sea.
Parakeets	High pitched chirping, flutter wings, fly at night, stay on fence, die.
Reptiles	Come out of hibernation.
Crocodiles	Call, leave the water for land or leave cages for the forest.
Snakes	Come out to the open in winter, swarm in bamboo clumps in summer.
Turtles	Wake from hibernation, climb on others apparently in panic, run.
Crabs	Leave wet habitats and crawl ashore, large numbers found dead.
Fish	Float and align in one direction, leap out of water, move violently, die.
	Turn upside down, act as if in turmoil, swarm, bigger fishing catches.
	Deep sea fish appear near surface, do not eat, sea fish swim up rivers.
Eels	Crowd onshore, disappear.
Insects	
Ants	Leave habitats carrying their eggs, swarm, enter houses.
Bees	Evacuate hives in a frenzy, buzz agitatedly and sting aggressively .
Cockroaches	Swarm close to metal ware.
Dragonflies	Swarm and fly in one direction .
Earthworms	Come out of soil, aggregate.
Flies	Swarm and cling to sweaty skin, fly in circles, rotate.
Silkworms	Parallel alignment.

Table 2.2 Plant anomalies before earthquakes.

Blooming ahead of season		
Potato	Two months	Vines bloom.
Apricot	Six weeks	Trees bloom in winter.
Early flowering & early crops		
Rice	A few weeks before	Small plants, early crops, bar-code leaves.
Orchid	One day before	Sways without wind.
Mimosa	At or just before	Closes leaves and droops.
Tree leaves	Just before	Shake without wind.

Table 2.3 Malfunctioning home electric appliances before earthquakes.

Appliance	Behavior
Car navigators	Fluctuation of the pointer arrow.
Clocks (quartz)	Stopping or sudden movements of the second hand. Fast forward and backward movement or delayed movement.
Fluorescent lamps	Dimming of light as during thunderstorms.
Intercoms	Spontaneous buzzing sounds, or not functioning.
Mobile phones	Ringling & light but no record of caller. Do not function, make odd sounds.
Radio (AM)	Spontaneous switching and loud sounds, pulsed noise.
Refrigerators	Strange compressor noises.
TVs	Spontaneous switching, speckling and flicker. Barber-pole color, lines, image distortion, white bands, loss of color, reversion to black and white, channel fluctuations

Table 2.4 Earthquake precursor phenomena in the sky and atmosphere.

Phenomena in the sky	Preseismic (time)	Coseismic
Earthquake light (EQL)	A day or a few hours	Flash and arc just before
Earthquake fog (EQF)	A few hours or just before	Sudden dense fog
Earthquake cloud (EQC)	A few days, 8 days	A dragon cloud appears
Yellow sky	A day	Becomes dark
Short rainbows	A few days	...
Haloed sun	A day to a few hours	...
Elongated or red moon	A day	...
Stars appear close	A day	...

Note: Tables in this chapter may frequently be referred to, together with the proverbs in Chapter 1, if people wish to acquaint themselves with earthquake precursor phenomena.