basic data for ISMR used in these experiments have been received from the rainfall data published by Parthasarathy *et al.*[6].

The single scientific motivation behind generating and publishing these experimental forecasts has been to carry out an objective field evaluation of the proposed method. One of the major drawbacks of NN (or, specifically CN) simulation is the absence of an (obvious and conventional) causal (dynamical) picture. The chief merit of the methodology therefore has to be derived from its forecast skill. The experimental forecasts, generated and published well ahead of the season, can help to build up a (statistically) acceptable estimate of the reliability and the skill of the method.

**Table 1.** A summary of performance of CN forecast

| Year | CN forecast† | Observation† |
|---|---|---|
| 1995 | 98 | 110 |
| 1996 | 95* | 103 |
| 1997 | 98 | 102 |
| 1998 | 107* | 106 |
| 1999 | 98 | 96 |
| 2000 | 91* | 92 |
| 2001 | 95–97% | 91 |

*Forecast made 2 – seasons in advance, i.e. 1996 forecast made before 1995 monsoon.
†Percentage of mean: Mean ISMR adopted in this table = 887 mm.

**Table 2.** Experimental CN forecasts of ISMR for 2002 and 2003

| Year | Rainfall (mm) | Percentage of long-period mean (%) | Error limit (%) |
|---|---|---|---|
| 2002 | 869 | 99 | 3 |
| 2003 | 919 | 104 | 4.5 |

With this philosophy, we record here our experimental forecasts of ISMR for the years 2002 and 2003 (Table 2).

The experimental forecasts recorded here is an ensemble average; the ensemble forecasts are generated by changing certain configurational parameters of the CN. The error bars in Table 2 thus represent ensemble standard deviations. The long-period mean ISMR adopted here is 887 mm.

Thus, as per criteria of India Meteorological Department, both the years 2002 and 2003 are likely to be normal monsoon years. A peculiarity of the forecasts presented here is worth noting: observationally (over the past hundred years or so), the longest spell of consecutive normal monsoon years is 13; we are thus at the edge of a shift to draught/excess year. However, our forecasts for both 2002 and 2003 are quite close to the long-term mean. It is worth emphasizing, however, that our forecasts are precise numbers with error bars as indicated. In other words, if the monsoon is normal, our forecasts may still be erroneous if the difference between the observed and the predicted values differed significantly from the indicated error bars.

We want to re-emphasize that the sole purpose of these experimental forecasts is to develop an objective and robust estimate of the skill of the CN forecast; they are not meant for any operational or commercial use. The CN model employed here uses only past ISMR as a predictor and, in that sense, is quite simple. However, the goodness of such a model has to be judged from its forecast skill, and not necessarily from its complexity. On the other hand, however, none of the years of experimental forecasts has a departure of more than one standard deviation of the observed data. Thus the skill of CN for large departures is yet to be proved in field evaluation.


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# A new record of a pterosaur from the Early Cretaceous of Korea

Pterosaurs are unsuitable for fossilization and are very rare in fossil records because their skeletons are fragile and are not preserved well[1–3]. The record of pterosaurs is represented by generally isolated, disarticulated and incomplete bones, but they have been discovered on all major land masses[4]. The Upper Triassic and Jurassic rocks have yielded a number of well-preserved pterosaurs, including *Dimorphodon*, *Rhamphorhynchus* and *Pterodactylus*, while the Cretaceous period has produced poorly preserved species such as *Dsungaripterus*, *Pteranodon* and *Quetzalcoatlus*[3].

South Korea reported the first pterosaur tracks in Asia and the largest tracks on record[5]. More than 4000 pterosaur tracks and the fragmentary remains of a pterosaur were discovered from the Uhangri Formation (Campanian) of the Late Cretaceous in South Korea[6]. However, the major portion of the fragmentary skeleton is still buried and not described as yet[7].

An isolated pterosaur bone was collected from the lacustrine Early Cretaceous Hasandong Formation (Hauterivian–Barremian) in the Gyeongsang Supergroup of South Korea. The

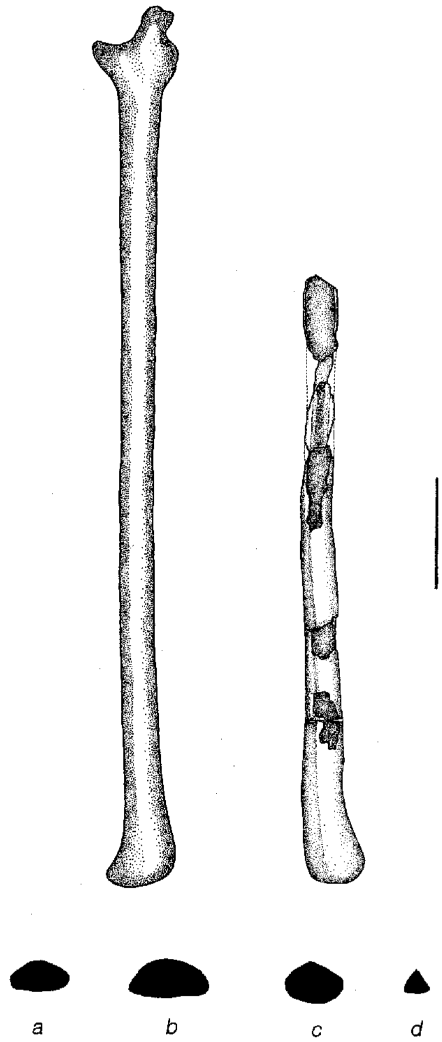


**Figure 1.** (Top right) SNU 1001; (Top left) First wing-phalanx of *Dsungaripterus weii* (IVPP V. 2777, modified from Young[16]). Scale bar equals 5 cm; (Bottom) Cross-sections of wing-phalanges and limb bones of pterosaurs; ***a***, SNU 1001, ***b***, wing-phalanges of *D. weii* (IVPP V. 2777); ***c***, Ulna of dsungaripteroidea from Inner Mongolia (IVPP V. 2778); ***d***, Tibia of dsungaripteroidea (IVPP V. 2779).

**Table 1.** Measurement (mm) of SNU 1001 and wing-phalanges *Dsungaripterus weii* (IVPP V. 2777)

| | Length | Proximal breadth | Distal breadth | Middle breadth | Thickness |
|---|---|---|---|---|---|
| SNU 1001 | 247* | | 26.5 | 15 | 10 |
| 1st wing-phalanx | 374 | 37 | 28 | 14 | 8 |
| 2nd wing-phalanx | 265 | 25 | 21 | 11 | 5.5 |
| 3rd wing-phalanx | 202 | 20.5 | 16.5 | 10.5 | 4.5 |
| 4th wing-phalanx | 150 | 9 | 8 | 9 | 4 |

*, Incomplete.

Gyeongsang Supergroup, a 900 m thick sequence in a non-marine deposit, has produced dinosaurs, plants, freshwater shells, fishes, turtles, crocodiles, insects and bird tracks (including web-footed species)[6,8–11]. The Hasandong Formation is a sandstone conglomerate with reddish and grey silty shales. It is known for dinosaur remains such as sauropod teeth, theropod teeth, a theropod claw, coprolites and eggs[12–15].

Based on its morphological characteristics, the pterosaur bone (Seoul National University (SNU) 1001) is an incomplete wing-phalanx (247 mm preserved length; Figure 1). The thickness of the cortical bone of the shaft is approximately 0.9–1.5 mm. The shaft of the SNU 1001 is dorso-ventrally compressed, which is a characteristic of wing-phalanges. Cross-sections pterosaur wing-phalanges are much flatter than those of the limb bones. Cross-sections of dsungaripterid ulnae are egg-shaped and those of tibiae are triangular in shape[16] (Figure 1). The femur from Shantung, China is rounded in cross-section[16].

On the basis of its stratigraphic position and size, SNU 1001 is assigned to the pterodactyloids. The overall construction of SNU 1001 more closely resembles the first wing-phalanx of *Dsungaripterus weii* from the Early Cretaceous of China (Institute of Vertebrate Paleontology and Paleoanthropology V. 2777) than phalanges of other pterosaurs (Figure 1). *D. weii* was a pterosaur with a wing-span of 3–3.5 m and relatively small orbits[17]. Like *Dsungaripterus* from China, SNU 1001 has relatively thick-walled bones. The proximal end of SNU 1001 is missing, but the distal end and most of the shaft are preserved well. The cross-sections of SNU 1001 and the first wing-phalanx of *D. weii* (IVPP V. 2777) show similarity in shape and size (Figure 1, Table 1). The distal end of SNU 1001 is 26.5 mm wide. The breadth at the middle of the shaft is 15 mm and the thickness is 10 mm. In *D. weii*, the measurements are 28 mm, 14 mm and 8 mm, respectively[16].

Pterosaurs have been discovered at more than 20 localities on the Asian continent, including India, China, Mongolia, Kazakhstan, Uzbekistan, and Japan[18]. The continental deposits of the Early Jurassic Kota Formation of India have produced pterosaur remains, including wing bones[18–20]. Recently, a wing-phalanx of a dsungaripterid was found in the Early Cretaceous Amagodani Formation of Japan and it is very similar to small dsungaripterid wing-phalanges from Wuerho, China[18].

The dsungaripterids are widespread in the continental deposits of the Early

Cretaceous of Asia[18]. SNU 1001 is also found in a non-marine deposit and confirms the conclusion by Unwin *et al.*[18] that dsungaripterids may have been continental pterosaurs. SNU 1001 represents the first pterosaur bone from the Early Cretaceous of Korea. The discovery of a pterodactyloid pterosaur suggests that the Early Cretaceous of South Korea was a unique Mesozoic fauna consisting of sauropod dinosaurs, theropod dinosaurs, birds (including web-footed ones), crocodiles, fishes and pterosaurs in a non-marine environment.


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