GEOLOGIC SETTING

The Lower Cretaceous Haman Formation in the Gyeongsang basin has been interpreted as a fluvial system dominated by sheetflood and floodplain deposits, with no perennial channel deposits present (Choi, 1986). Mudcracks are common, indicating subaerial exposure, although no pedogenic features have been described; none were observed at GISE.

The Haman Formation consists primarily of purple mudstone, siltstone, and fine-grained sandstone, commonly interbedded with mud drapes (Choi, 1986). One rock sample with planar beds and rip-up clasts was observed at GISE (Fig 4). The paleoclimate during deposition of the Haman Formation is thought to have been semiarid or arid (Choi, 1986).

The main slab of tracks and trackways discussed herein contains current ripples (S. I. fig 3A) and such invertebrate traces as Treptichnus, Steinichnus, and cf. Naktodemasis (S. I. fig. 3B–F), which are indicative of very shallow-water environments that experience subaerial exposure. Many float blocks associated with the locality also contained current ripples. The main slab is primarily fine-grained, yellow-grey sandstone with thin, dark purple-red silty drapes. Other track-bearing float blocks exhibit similar lithology and coloring.

SUPPLEMENTAL DISCUSSION

Implications for the depositional environment

The presence of several kinds of invertebrate trace fossils (Steinichnus, Treptichnus, and cf. Naktodemasis) indicates an alternating shallow, freshwater and subaerial environment. The Haman Formation has always been interpreted as an alluvial succession. The presence of current ripples on the EH1 floor slab (S. I. fig. 3A) support this interpretation. The presence of the bird tracks and other invertebrate traces, however, likely indicates a short periods of standing water
and subaerial exposure. *Steinichnus* indicates that the water table was near the sediment-air interface (Hasiotis, 2002, 2004). Subaerial exposure with algal or cyanobacterial growth as a sediment binder would preserve the tracks (e.g. Noffke and Krumbein, 1999). The lack of pedogenic features suggests that sedimentation rates were much higher than pedogenic rates (Hasiotis and Platt, 2012).

The presence of the *Ignotornis gajinensis* spoonbill-like traces and their overall complete similarity to modern black-faced spoonbill *Palatea minor* traces allows for a more specific interpretation of the depositional environment. Spoonbills feed using extrasensory electromagnetic organs on the bill (Swennen and Yu, 2004). Spoonbills do not feed on subaerially exposed sediment due to the uses of these extrasensory organs; therefore, there spoonbill-like feeding traces are strong evidence for the presence of water at the time of trackway production. Modern *P. minor* trackways with paired arcuate traces nearly identical in morphology to the trackways with arcuate marks from the Haman Formation were made in very shallow water that was 5–6 cm deep (Swennen and Yu, 2005). The spoonbills were observed feeding in deeper waters, and footprints were observed from these foraging sessions, but no arcuate scything traces were found alongside them when the spoonbills foraged in waters deeper than 6 cm (Swennen and Yu, 2005, fig 2b). This is due to the varying positions of the head in relation to depth of the water during feeding (Swennen and Yu, 2005, fig 1). The Haman Formation trackways were produced by something that had a very similar morphology to *P. minor* based on SL and foot parameters and, therefore, the length of the bill and leg of the Early Cretaceous spoonbill-like bird were slightly smaller than the modern *P. minor*. The water level must have been similar, but slightly more shallow, to that recorded by Swennen and Yu (2005) in order to leave the arcuate traces (Lockley and Harris, 2010; Kim et al., 2012).
REFERENCES


Figure 1: Locality map of the Gyeongsangnamdo Institute of Science Education (GISE) near Jinju, South Korea. Star represents the locality. Scale bar equals 7 km.

Figure 2: Specimen KS051 illustrating rip-up clasts found in the layer beneath the bird tracks. Arrows point to clasts.
Figure 3: Ripple marks and invertebrate traces found on EH1. (A): Ripple marks; note bird tracks (chalk arrow); (B-F): Invertebrate traces.
Figure 4: Modern web-footed bird tracks compared to fossil bird tracks from the Cretaceous of Korea. A: Franklin's Gull (*Lecucophaeus pipixcan*). Note outer toes curve inward towards toe III due to webbing; B: Spoonbill-like *Ignotornis gajinensis*; note outer toes are also curved towards toe III, although not as strongly as in A; C: *Hwangsanipes* from Haenam, Korea. Note strongly curved toes II and IV.
Figure 5: A shorebird-like track on KS064 with semipalmate webbing. Arrow points to webbing.

Note clear pad impressions on toe II.
Figure 6: Well-preserved spoonbill-like *Ignotornis gajinensis* showing webbing and line drawing.
Figure 7: KS005. Note *Koreanaornis* in red.
Figure 8: *Goeseongornipes* track showing abnormal morphology—likely due to twisting. Water was used to highlight the track and increase contrast.
Figure 9: Enigmatic trough-like trace on NHC-IC-003a. Line drawing represents enigmatic trough (T), a displaced ridge of sediment (SR) and clasts of displaced mud (M). Line drawing scale bar equals 3 cm.
TABLE CAPTIONS

Table 1- Single-track measurements of all spoonbill-like footprints (*Ignotornis gajinensis*) from GISE. II=Toe II, III=Toe III, IV=Toe IV, LII=Length of toe II, LIII=length of toe III, LIV=length of toe IV, WII=width of toe II, WIII=width of toe III, WIV=width of toe IV, FL=foot length, FW=foot width, R=right, L=left. †=estimated length or width, *=digit impression that was incomplete, usually due to the broken edge of the slab. Abbreviations and symbols are the same throughout. All measurements are in mm unless stated otherwise.

Table 2- Single-track measurements from selected samples of *Koreanornis* from GISE and GISE specimens found in outside repositories.

Table 3- Single-track measurements of all *Geoseongornipes* from Exhibit Hall 2.

Table 4- Single-track measurements of selected unassigned avian tracks from GISE.

Table 5- Measurements of enigmatic traces found on NHC-IC-002A.

Table 6- Multiple-track measurements of the floor slab of Exhibit Hall 2.

Table 7- Multiple-track measurements of KS064. Track numbers marked with a "?" indicate a question about their affinity with that trackway. "Away" indicates that the foot was turned outward from the midline of the trackway. "Curve" indicates trackway was sinuous at that point.