Xing Lida sizes a sauropod scapula.

THE FOOTPRINTS OF GIANTS

Paleontologist Xing Lida is racing China's rapid growth to find the tracks of dinosaurs and map their ancient habitats

By **Kathleen McLaughlin**, *in Linyi, China*

Just after daybreak, a three-vehicle caravan arrives at the edge of a lake by this remote village on the coast of China's Yellow Sea, not far from Confucius's birthplace. The occupants pile out; grab chisels, brooms, and chalk; and, after a quick survey of the area, start carving through a layer of hard-packed dirt. The stone beneath is curiously pockmarked. The team meticulously marks, measures, and photographs each crater and depression, all the while brushing off questions from villagers befuddled by the interest in this barren, untillable plot of land.

The diggers don't want to reveal that they are paleontologists, lest word spread that the land holds potentially valuable dinosaur tracks. The architect of that strategy of silence, and the leader of the dig, is Xing Lida, a buoyantly boyish paleontologist from the China University of Geosciences in Beijing. It is the team's first visit to the site, which was spotted by one of Xing's friends, a local artist who is an amateur dinosaur track hunter. Xing, who is 35 but looks a decade younger, sings and jokes with the team members as they work, his excitement rising as he begins counting prints and realizes the scale of this find. The U.S. football field–sized plot holds hundreds—possibly a thousand—well-preserved footprints from dinosaurs of various sizes and ages, representing at least seven species.

"It's really beautiful, so much more than we expected," Xing says. A hundred million years ago, he speculates, the site was the equivalent of a watering hole on the Serengeti today, a gathering place for sauropods and birds, meat-eating theropods, and possibly the bipedal grazers called ornithopods. The locale could be one of China's top 10 dinosaur footprint sites and a remarkable find globally, Xing says. A thorough study of the site, which could take months, could yield clues for his chief obsession: unraveling where dinosaurs lived on the ancient landmass that is now China, and how they interacted.

Xing is known for what he considers his hobby: his unmatched collection of feathers and fossils preserved in amber. But his first love is dinosaur footprints, which are often overshadowed by fossils but are a vital source of information on dinosaur ecology and behavior. His passion has taken him to more than 100 sites scattered through all but two of China's 33 provinces. He was the first to study most of them, having learned about the sites through his deep network of amateur fossil hunters. He has also dug in the Middle East, South Korea, and the United States.

Xing does his surveys at a breakneck pace. He learned rock climbing because some of the best-preserved tracks are on rock layers that geologic forces have tilted to vertical. His rapid-response excavations have resulted in more than 90 papers since 2010. They report on the distribution of species in time and space—often filling gaps in the spotty fossil record—and describe the ancient habitats and the dinosaurs' behavior and interactions. Xing is close to stitching the individual findings into a comprehensive map of habitats and ranges for dinosaurs throughout east Asia.

China has seen many spectacular fossil discoveries in recent years, and Xing's map will help put those in context. His effort mirrors what has been done in the United States, but for China it is unprecedented, says Richard McCrea, a fossil footprint specialist at Peace Region Paleontology Research Centre in Tumbler Ridge, Canada, and a mentor to Xing. "He is essentially building the comprehensive framework for fossil track studies for China, where before there were only a few sporadic reports," McCrea adds.

XING'S DINOSAUR OBSESSION started with a Japanese TV cartoon when he was just 6 years old, the son of two physicians in the remote southern Chinese region of Chaoshan. The program had it all: time travel, a beauti-

PHOTOS: (LEFT TO RIGHT) XING LIDA; LU YONG

This newly discovered site in Linyi, China, holds upwards of a thousand footprints from at least seven dinosaur species.

ful princess, laser weapons—and dinosaurs. "From then on, I bought all the books about dinosaurs in the bookstore and started to understand these amazing lives," Xing recalls.

While still a teenager, he built a database of some 900 dinosaur names with Chinese translations—a tool that his colleagues still use. He also wrote to Martin Lockley, then a fossil footprint expert at the University of Colorado in Denver, asking for advice on finding dinosaur tracks. Lockley sent Xing a packet of information. As an undergraduate in 2007, Xing published his first scientific paper, describing Cretaceous dinosaur fauna that had left tracks in ancient mud in Sichuan province.

After finishing college in 2009, Xing briefly detoured from dinosaurs to become a newspaper science reporter. But just over a year later, he enrolled at the University of Alberta in Edmonton, Canada, to study paleontology. Last year he earned his Ph.D. at the China University of Geosciences. Along the way, his contacts with Lockley blossomed into friendship and collaboration. "I met him in Beijing perhaps 10 years ago, and by 2012 we had published our first joint paper on footprints," Lockley says. "We have since published more than 60, which averages one a month."

Those papers cover just about every aspect of paleontology, but they overwhelmingly rely on footprints to serve as new evidence of when and where dinosaur species existed and how they interacted. Xing has reported the oldest sauropod trackways and ornithischian prints found in China. That finding was evidence that those dinosaurs roamed Asia 190 million to 200 million years ago during the Early Jurassic, earlier than previously thought. One examination of prints in Guangdong province revealed that duck-billed hadrosaurs; small, birdlike theropods; and pterosaurs mingled along a Late Cretaceous lakeshore and were likely preyed on by larger theropods—none of which had left any fossils. And Xing has proved willing to challenge conventional wisdom. In *Scientific Reports* in February 2016, he and his colleagues reported that they had examined sauropod tracks in central China's Gansu province and concluded that the beasts did not swim, contrary to a long-standing view. Faint footmarks on what had been a lakebed suggested the animals were buoyed by water, but deeper holes left by their claws implied that, instead of swimming, they gripped the bottom for traction or balance.

"Xing is without doubt the leading fossil footprint researcher in China," Lockley says. Yet Xing's prolific pace of publication has raised concern in China's small world of paleontology, along with suggestions that he may be cutting corners. "In this community, some people suspect he publishes too much," says Xu Xing (no relation), a noted paleontologist at the Institute of Vertebrate Paleontology and Paleoanthropology at the Chinese Academy of Sciences in Beijing. But Xu Xing, who mentored Xing Lida in graduate school, says his younger colleague's work is sound.

Xing is in a hurry for a good reason. With China's rapid industrial development in recent years, new fossil sites turn up constantly. But they are often destroyed just as quickly, something Xing learned the hard way. Several years ago, his team discovered a fossil footprint site in Sichuan province. A local mining company with plans for the land heard that the scientists wanted officials to protect the prints. "They went out in the middle of the night and completely broke up the whole site," Xing recalls. He and his colleagues had managed to document just a fraction of the footprints.

Since then, Xing has adopted a cautious strategy for new sites, including keeping quiet about what the team has found. At Linyi, he has broken the silence in one important way: by inviting paleontologists from a nearby university to join the excavation. Their support could be crucial in persuading the local government to preserve the site and possibly turn it into a fossil footprint park.

SO CONSUMED IS XING with dinosaurs that they are even at the center of his recreation: building a collection—now including 200 specimens—of dinosaur feathers preserved in amber. Using money from his extended family, Xing buys the amber from local jewelry markets in Myanmar. (Some paleontologists object to removing fossils from their country of origin. Xing says that if Myanmar institutes mechanisms to protect such samples, he'll consider returning them.) The samples also provide grist for publications. In a December 2016 paper in *Current Biology*, Xing and Ryan McKellar of the Royal Saskatchewan Museum in Regina, Canada, described their team's discovery of a feathered baby dinosaur tail in a chunk of amber 99 million years old.

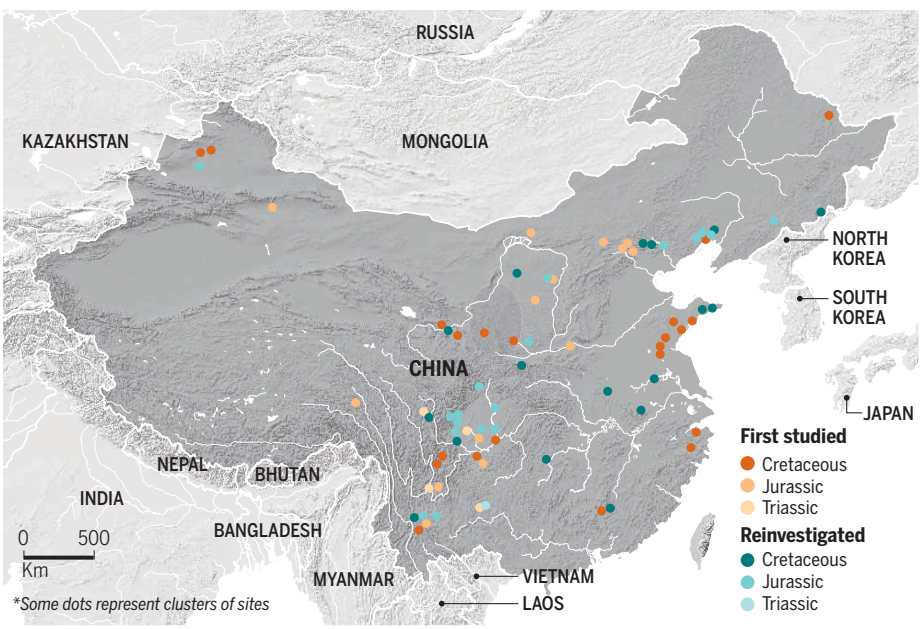
That finding got worldwide attention (*Science*, 9 December 2016, p. 1209). Earlier this month, in *Gondwana Research*, he reported another treasure in amber from Myanmar: the spectacularly well-preserved remains of a 99-million-year-old baby bird.

But Xing expects the less photogenic science of dinosaur footprints to make a bigger impact. Back in Linyi, he is thrilled by the level of detail preserved in the tracks. Even toes can be discerned in a few of the sauropod prints. The site will be one more brushstroke in the panorama Xing hopes to create. "In maybe 2 or 3 years, we will be able to explain which dinosaurs China had, where they lived, and in which different eras," he says.

The timeline is ambitious, but Xing is racing China's pell-mell development. "We need to move quickly and get more data before bad things happen," he says. "They are precious; dinosaur footprints are great records from nature, not just stone pits." ■

All over the map

Xing Lida has investigated dinosaur tracks at more than 100 sites across China, many found by an extensive network of amateur fossil hunters. He hopes to combine his surveys into a map of ancient dinosaur habitats.



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The footprints of giants

Kathleen McLaughlin

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