Catalogue of Late Jurassic Vertebrate (pisces, reptilian) Specimens from Western Cuba

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ABSTRACT

Vertebrate remains are relatively well known in Late Jurassic deposits of western Cuba. The fossil specimens that have been collected so far are dispersed in museum collections around the world and some have been lost throughout the years. A reassessment of the fossil material stored in some of these museums' collections has generated new data about the fossil-bearing localities and greatly increased the number of formally identified specimens. The identified bone elements and taxa suggest a high vertebrate diversity dominated by actinopterygians and reptiles, including: long-necked plesiosaurs, pliosaurs, metriorhynchid crocodilians, pleurodiran turtles, ichthyosaurs, pterosaurs, and sauropod dinosaurs. This assemblage is commonly associated with unidentified remains of terrestrial plants and rare microorganisms, as well as numerous marine invertebrates such as ammonites, belemnites, pelecypods, brachiopods, and ostracods. This fossil assemblage is particularly valuable because it includes the most complete marine reptile record of a chronostratigraphic interval, which is poor in vertebrate remains elsewhere. In this contribution, the current status of the available vertebrate fossil specimens from the Late Jurassic of western Cuba is provided, along with a brief description of the fossil materials.

Key words: Late Jurassic, Oxfordian, dinosaur, marine reptiles, fish, western Cuba.

INTRODUCTION

Since the early 20th century, different groups of collectors have discovered a relatively rich and diverse vertebrate assemblage in the Late Jurassic strata of western Cuba, which has been only partially investigated (Brown and O'Connell, 1922; De la Torre y Callejas, 1949; De la Torre y Madrazo and Cuervo, 1939; De la Torre y Madrazo and Rojas, 1949; Gasparini and Iturralde-Vinent, 2006, and references therein; Gregory, 1923; Iturralde-Vinent and Norell, 1996; Judoley and Furrazola-Bermúdez, 1965).

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The fossil material was recovered from lenticular calcareous concretions within the Oxfordian Jagua and Francisco Formations, and to a lesser extent from well-bedded limestones of the Tithonian Guasasa and Artemisa Formations. These stratigraphic units crop out at several localities in the Guaniguanico mountains of the Pinar del Rio province of western Cuba.

In the Oxfordian fossil-bearing strata more than seventy rather well-preserved reptile specimens have been collected, and more than five hundred fish remains, some of which have been assigned to family, genus, or species. Reptiles within this fossil assemblage include two rhamphorhynchid pterosaur taxa (*Nesodactylus hesperius*, *Cacibupteryx caribensis*), a cryptoclidid plesiosauroid taxon (*Vinialesaurus caroli*), a medium-sized pliosauroid (*Gallardosaurus iturraldei*), indeterminate rhacheosaurin crocodilians, a fragmentary specimen of pleurodiran turtle (*Caribemys oxfordiensis*), several unidentified ichthyosaurs including ophthalmosaurian elements, and at least one camarasaurid sauropod bone (Gasparini and Iturralde-Vinent, 2006; Young, 2013).

Identifiable remains of bony fish (actinopterygians) are also common including the following taxa: *Lepidotes gloriae*, *Gyrodus macrophthalmus cubensis*, *Caturus deani*, *Sauropsis woodwardi*, *Eugnathides browni*, *Leptolepis euspondylus*, *Luisichthys vinalesensis*, *Aspidorhynchus arawaki*, *Pholidophorus* sp., *Hypsocormus leedsi*, which are sometimes fossilized in three dimensions (Arratia and Schultze, 1985; Gregory, 1923; White, 1942; and others). Disarticulated bones of fish (provisionally identified as *Hypsocormus* sp.), and unidentified plesiosaur remains have been unearthed from Tithonian strata (Furrazola-Bermúdez in Gasparini and Iturralde-Vinent, 2006; Judoley and Furrazola-Bermúdez, 1965; Sánchez-Roig, 1920). Fragments of tree trunks, branches, and detrital vegetal material, and an assortment of marine invertebrates including ammonites, belemnites, pelecypods, brachiopods, and ostracods, are associated with fish and reptiles in the mid-to early-Late Oxfordian strata (Gasparini and Iturralde-Vinent, 2006; Iturralde-Vinent and Norell, 1996; Pszczólkowski, 1978; Wierzbowski, 1976).

The Cuban Late Jurassic vertebrate assemblage is important not only for its high taxonomic diversity and relative abundance, but it also includes the most complete marine reptile record for the mid-to early-Late Oxfordian as yet discovered (Gasparini and Iturralde-Vinent, 2006). This chronostratigraphic interval is poor in marine reptiles in other parts of the planet, and those which have been collected are often fragmentary (Gasparini and Iturralde-Vinent, 2006; Young, 2013). Furthermore, the presence of marine forms that are closely related phylogenetically in Late Jurassic-Early Cretaceous American and European deposits, underline the outstanding position of the Oxfordian early Caribbean taxa of western Cuba. However, only in the last decade, taxonomic, biogeographic and paleogeographic studies have been accomplished (Gasparini and Iturralde-Vinent, 2006; Iturralde-Vinent, 2004; Iturralde-Vinent and Norell, 1996; Pszczólkowski, 1978, 1999; Wierzbowski, 1976).

Late Jurassic vertebrate specimens of Cuba are dispersed in museum collections in Cuba, Puerto Rico, the United States of America and Great Britain, but unfortunately, some are known to have been lost (Table I). Most of the Late Jurassic fish and reptile fossil-bearing localities in Cuba were poorly known prior to the work of Iturralde-Vinent and Norell (1996), but since the publication of this synoptic catalog, new localities and fossil materials have been discovered, and new taxa named and/or revisited. In Cuba, the Late Jurassic fish-bearing localities were not catalogued before and the majority of existing specimens are awaiting a formal identification.

The main objective of this paper is to provide an assessment of the current status of the available fossil vertebrate specimens of the Late Jurassic of western Cuba, and present an updated catalog including previously unpublished specimens and localities.

PREVIOUS WORK

Alexander von Humboldt inferred the existence of Jurassic rocks in the western part of the island at the beginning of the 19th century, but he did not provide paleontological evidence. Actually, the first to prove the occurrence of Jurassic strata was the Spanish mining engineer Manuel Fernández de Castro, who reported Jurassic ammonites in the Pinar del Río province in 1881. However, these fossils were neither illustrated nor identified. The first author to properly identify rocks of the Jurassic period was the outstanding Cuban naturalist Don Carlos de la Torre y Huerta (De la Torre y Huerta, 1909, 1910*a*, 1910*b*), who reported the occurrence of Jurassic fossils in Pinar del Río. Between 1911 and 1919, Barnum Brown (American Museum of Natural History) visited Cuba to collect fossils guided by Carlos de la Torre y Huerta and was impressed by the Jurassic fauna of the Viñales region. The occurrence

Table 1. Repositories and abbreviations for material investigated in this paper.

	Repository	Abbrev.	Location	Fish	Reptile
01	Museo Nacional de Historia Natural de Cuba	MNHNCu	Habana, CUBA	*	*
02	Instituto de Geología y Paleontología de Cuba	IGP	Habana, CUBA	*	*
03	Antonio Núñez-Jiménez Foundation for Nature and Humanity	FANJ	Habana, CUBA	*	*
04	Museo "Campismo Dos Hermanas"	MDH	Pinar del Río, CUBA	*	*
05	Museo de Viñales	MV	Pinar del Río, CUBA	*	
06	Gallardo's collection	GC	Pinar del Río, CUBA	*	
07	American Museum of Natural History	AMNH	New York, USA	*	*
08	British Museum of Natural History	NMH	London, UK	*	
09	Museum of Comparative Zoology	MCZ	Cambridge, USA	*	
10	National Museum of Natural History	USNM	Washington, D.C, USA	*	*
11	Museum of Paleontology of University of California	UCMP	Berkeley, USA	*	*
12	Texas Memorial Museum of University of Texas	TMM	Austin, Texas, USA	*	
13	University of Puerto Rico, Paleontology Collection	UPRMP	Mayagüez, PUERTO RICO	*	

of Oxfordian beds in western Cuba bearing ammonites, fish, and marine reptiles was consequently reported by Brown and O'Connell (1919, 1922).

Perhaps the earliest paper describing the Cuban Jurassic fish fauna was by Sánchez-Roig (1920), who collected fossils with his father and Juan Gallardo concurrently with the Brown expeditions. He illustrated some rare Tithonian fish remains, which have been stored in the British Museum of Natural History since 1924 (Z. Johanson, *personal commun.*, 2009) and Gregory (1923) described several new fish taxa treasured at the American Museum of Natural History. Since then, few new taxa have been published from museum collections in the United States of America (Arratia and Schultze, 1985; Brito, 1997, 1999; Thies, 1989; White, 1942).

Others collectors, active during the first half of the 20th century, includes: América Ana Cuervo, Ricardo De la Torre y Madrazo, Julio de Quesada, Theodore E. White, Thomas Barbour, David H. Dunkle, Julian Millo, Carl Parsons, and Charles W. Hatten. Most of these early collecting works were accompanied by the late Juan Gallardo, an experienced Cuban fossil hunter, whose later findings, including well-preserved actinopterygians, plesiosauroids, pliosauroids, pterosauroids and the pleurodiran turtle, have strongly contributed to the present knowledge of the Cuban Jurassic fauna. These vertebrate fossil specimens were stored in private Cuban collections, at the Museo Felipe Poey of the University of Havana, and at several North American institutions including the Smithsonian Museum of Natural History in Washington D.C., the American Museum of Natural History in New York City, the Museum of Paleontology at Berkeley, and the Museum of Comparative Zoology at Harvard. During the second half of the 20th century additional samples were collected by Antonio Núñez-Jiménez (housed at the Antonio Núñez-Jiménez Foundation for Nature and Humanity), A. Pszczólkowski, R. Myczyński, C. Judoley, G. Furrazola-Bermúdez and R. Gutiérrez-Domech (stored at the Instituto de Geología y Paleontología de Cuba).

With the exception of a rhamphorhynchid pterosaur in the collection of the American Museum of Natural History (Colbert, 1969), most of the Cuban Late Jurassic reptile specimens were poorly prepared, inadequately studied, and improperly allocated taxonomically before 1996. These specimens were usually identified as ichthyosaurs (De la Torre y Madrazo and Cuervo, 1939; De la Torre y Madrazo and Rojas, 1949) or sauropod dinosaurs (De la Torre y Callejas, 1949).

In the late eighties, M. Iturralde-Vinent started a new stage of research relocating the historic Jurassic vertebrate-bearing localities with the late Juan Gallardo and his oldest son. Also in the early nineties, M. Iturralde-Vinent visited every paleontological collection in Cuban museums, the Cuban collections in museums in the United States of America, and the British Museum of Natural History. Consequently, a detailed catalog of Cuban Late Jurassic reptile specimens and localities, with a preliminary discussion of the taxonomic position of the known reptile taxa was

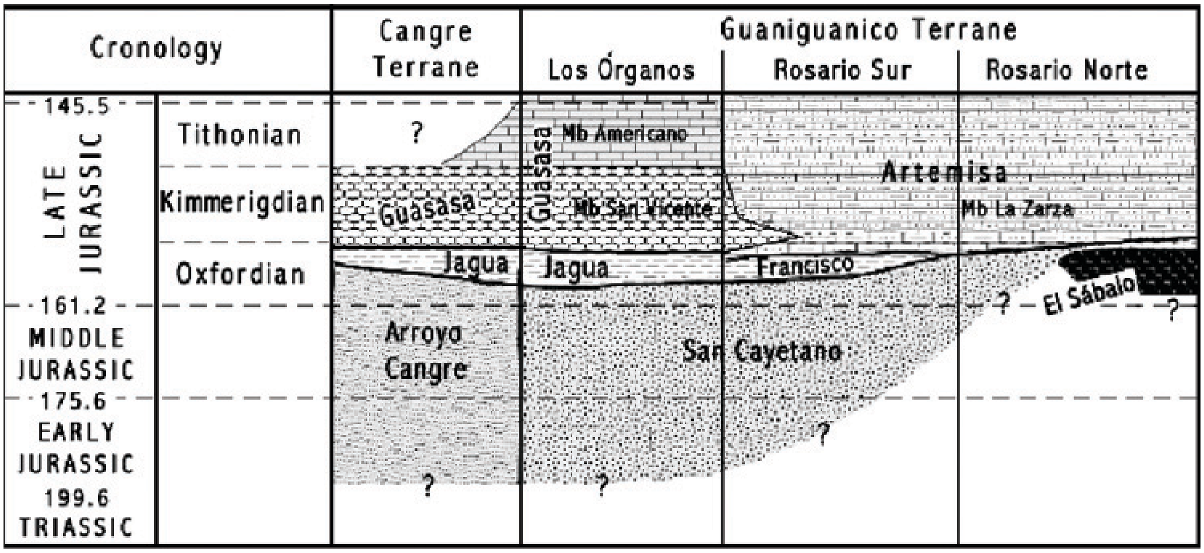

Figure 1. Jurassic stratigraphic scheme of the Cangre and Guaniguanico terranes, simplified from Iturralde-Vinent and Pszczólkowski (2012).

completed (Iturralde-Vinent and Norell, 1996). During this process a Jurassic vertebrate collection was created in the Museo Nacional de Historia Natural de Cuba, with materials obtained by means of collection, donation, and exchange.

In 1999, an important cooperation between the Museo Nacional de Historia Natural de Cuba and the Museo de Historia Natural de La Plata in Argentina began. The Cuban collections were revisited and part of the fossil material was sent to the Museo de Historia Natural de La Plata to be prepared and examined. In the meantime, taxonomic, biogeographic and paleogeographic investigations of the fossil-bearing localities were continued (De la Fuente and Iturralde-Vinent, 2001; Fernández and Iturralde-Vinent, 2000; Gasparini, 2009; Gasparini and Iturralde-Vinent, 2001; Gasparini *et al*., 2002, 2004; Iturralde-Vinent, 2004). The Cuban-Argentinean cooperation resulted in the discovery and redefining of several new taxa of marine crocodile, ichthyosaurs, plesiosauroids and pterosauroids.

The results of these investigations, including taxonomy, stratigraphy, taphonomic interpretations, and paleobiogeography were summarized by Gasparini and Iturralde-Vinent (2006) and in a popular book for the general public (Iturralde-Vinent and Gasparini, 2014).

GEOLOGICAL SETTING

The Jurassic section exposed in the Pinar del Río Province in western Cuba (Sierra de los Órganos and Sierra del Rosario) includes vertebrate-bearing units of Oxfordian and Tithonian age (Figure 1). Detailed geological descriptions of the Mesozoic formations in western Cuba include those of Herrera (1961), Iturralde-Vinent and Pszczólkowski (2012), Pszczólkowski (1978, 1999), Wierzbowski (1976), as well as a synthesis of the most important fossil-bearing formations by Gasparini and Iturralde-Vinent (2006), and Iturralde-Vinent and Norell (1996). The Guaniguanico cordillera, from both a stratigraphic and tectonic standpoint, has been subdivided into several units (Figure 1): Cangre and Guaniguanico Terrane, which include the Los Órganos, Rosario Sur, Rosario Norte, and Guajaibón belts; described lately by Iturralde-Vinent and Pszczólkowski (2012).

Data collected for this study was insufficient to solve some ambiguous localities such as "Near Viñales" and "Near Viñales town", which could be anywhere between Puerta del Ancón, Laguna de Piedra, and Hoyos de San Antonio (Iturralde-Vinent and Norell, 1996). However, during the course of our research, new localities containing fish and unidentified reptiles were added to those already known (Figure 2). Generally, a palaeontological site represents about one square kilometer, although their limits are poorly defined. Fossil-bearing terrains include the slopes, creek, and farmlands near the karstified limestone hills (locally named "mogotes"). Laminated calcareous concretions of lenticular shape commonly occur at the surface, many with external casts of ammonites or bones extruding from their surfaces.

The majority of the fossil vertebrates material found in Pinar del Río, comes from a mid-to early-Late Oxfordian horizon named the Jagua Vieja Member of the Jagua Formation of Sierra de los Órganos. Palaeoenvironmentally, these marine deposits represent a low-energy, near shore, lower shelf, with water depths less than 100 meters (Wierzbowski, 1976). They were deposited during a transition from a siliciclastic deltaic continental plain (Early Oxfordian and older), into a marine carbonate shelf that was shallow and muddy (Late Oxfordian-Kimmeridgian) (Gasparini and Iturralde-Vinent, 2006; Iturralde-Vinent 2004; 2006).

The mid-to early-Late Oxfordian Jagua Formation outcrops in the Sierra de los Órganos belt, and consists of approximately 160 meters of shale and limestones overlying the San Cayetano Formation (Pszczólkowski, 1978). The Jagua Vieja Member of the Jagua Formation, a reach fossil-bearing horizon, consists of black, laminated, bituminous shales with thin intercalations of argillaceous, micritic to biomicritic limestones up to 60 meters thick, containing lenticular diagenetic calcareous concretions with fairly abundant fossils (Pszczólkowski, 1978). Fossils found in this member include: abundant unidentified terrestrial plant remains, trace fossils (*Teredolites clavatus*), sepioids (*Voltzia palmeri*), bivalves (*Liostrea* sp., *Ostrea* sp., *Plicatula* sp., *Exogira* sp., *Gryphaea* sp., ?*Posidonomya* sp.), small-sized gastropods, fora-

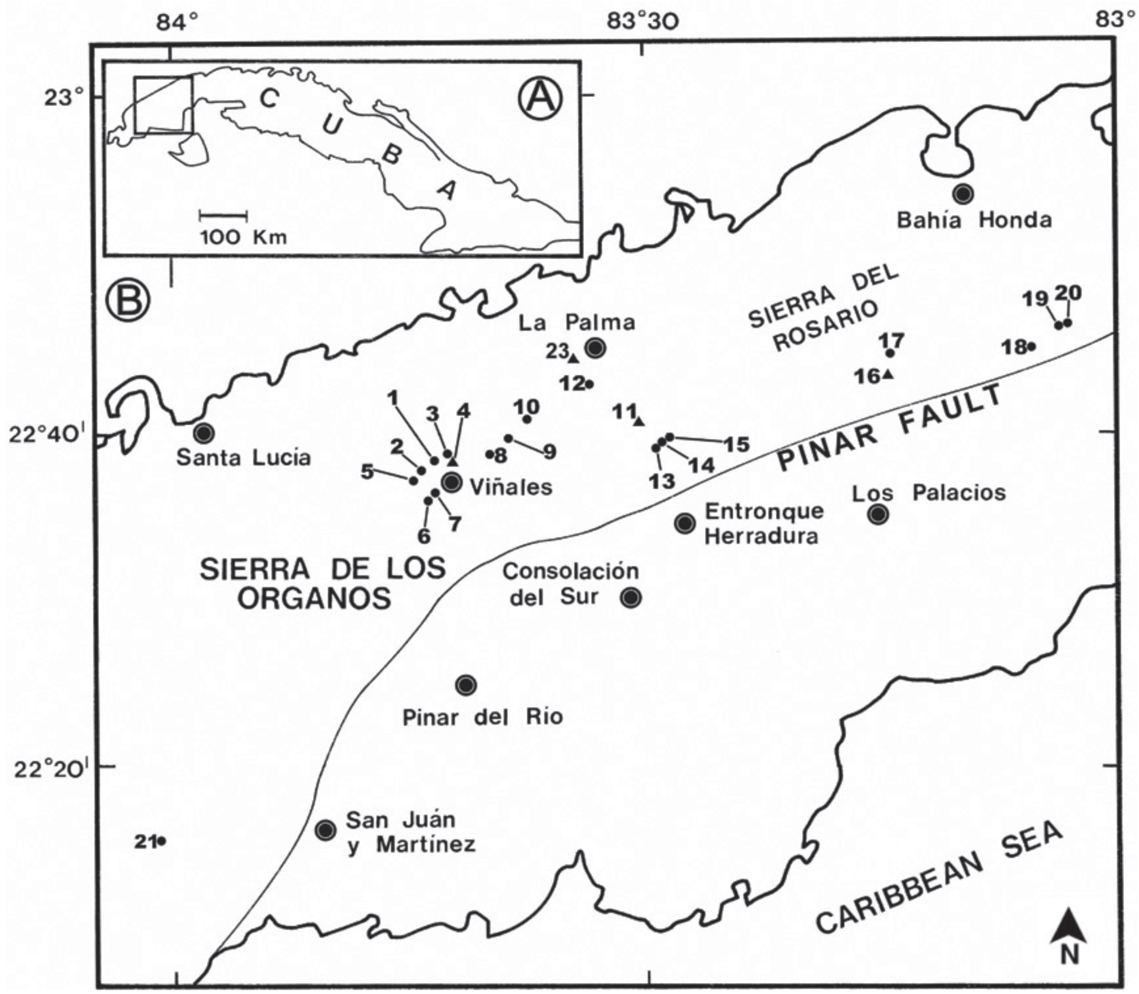

Figure 2. Location of the Cuban Late Jurassic vertebrate-bearing localities (Updated from Iturralde-Vinent and Norell (1996) and Gasparini and Iturralde-Vinent (2006). **A)** Position of the area investigated; ***B)*** Simplified map of Pinar del Rio Province. Black circles represent Oxfordian localities: **(1)** Puerta de Ancón, **(2)** Near Viñales, **(3)** Laguna de Piedra (Norte), **(5)** Mogote la Penitencia, **(6)** Valle los Jazmines, **(7)** Viñales Town, **(8)** Hoyos de San Antonio, **(9)** Mogote La Mina, **(10)** Jagua Vieja, **(12)** Mogote Pico Chico, **(13)** Hoyo del Palmar, **(14)** Hoyo de la Sierra, **(15)** Caiguanabo, (17) Rangel Arriba, **(18)** Puerta de la Muralla, **(19)** Near Cinco Pesos, (20) 1km N of Cinco Pesos, **(21)** Punta de la Sierra. Black triangles represent Tithonian localities: **(4)** Laguna de Piedra (Sur), **(11)** Hacienda El Americano, **(16)** Rancho Mundito, **(23)** Vega Nueva.

minifera (*Conicospirillina basiliensis*), belemnites and ammonites (typically belong to Perisphinctidae, less numerous amounts of Glochiceratidae, and Aspidoceratidae, among others). According to Wierzbowski (1976), the ammonite assemblage from the Jagua Vieja Member represents the *Gregoryceras transversarium* and *Perisphinctes bifurcatus* Chrons of the Middle Oxfordian age, but later, Myczyński *et al*. (1998) correlated this ammonite assemblage with the *Perisphinctes bifurcatus* Chron of Late Oxfordian age. Vertebrates fossils embrace actinopterygian fishes and reptiles that include rhamphorhynchid pterosaurs (*Nesodactylus hesperius*, *Cacibupteryx caribensis*), ophthalmosaurian ichthyosaurs and an unidentified ichthyosaur skull, a cryptoclidid plesiosaur (*Vinialesaurus caroli*), a medium-sized pliosaurid (*Gallardosaurus iturraldei*), indeterminate thalattosuchian, rhacheosaurin crocodylomorphs, a marine pleurodiran turtle (*Caribemys oxfordiensis*), and at least one camarasaurid sauropod (Gasparini and Iturralde-Vinent, 2006; Gregory, 1923; Iturralde-Vinent and Norell, 1996; Pszczólkowski, 1978; Wierzbowski, 1976; Young, 2013). In the Sierra del Rosario, an equivalent unit of the Jagua Formation is the Francisco Formation, which consists of black shales, micritic limestones, and thin sandstone intercalations, about 25 meters thick, containing a few small to medium calcareous concretions with rare bivalves, ammonites, fish and plant remains (for details see Kutek *et al.*, 1976; Pszczólkowski, 1999). According to Kutek *et al.* (1976, see fig. 4, fig. 5), unidentified fish material was found in two localities from exposures near the Cinco Pesos area, located about 10 km NW of San Cristóbal.

The fossil-bearing concretions are highly variable in size, from a few centimeters to nearly one meter in diameter, and are composed of laminated micritic limestone or dolostone and calcareous siltstone. It have been suggested an early diagenetic origin for the fossiliferous concretions (Wierzbowski, 1976). In the local vernacular these concretions are known as "quesos" (cheese), "jicoteas" (tortoise), or "jocoteas" (colloquial misspelling of jicotea). For this reason, some fish specimens housed in the Museum of Comparative Zoology have been improperly labeled as originating in the "horizon Camada de Quesso" [*sic*] which is not a valid stratigraphic unit, but it is most probably the Jagua Vieja Member of the Jagua Formation.

In the concretions, saurian bones are usually found as disarticulated or isolated elements, but also fragmentary skulls and two or more articulated vertebrae are often preserved. The bones are three-dimensional, fossilized as a dark black microcrystalline limestone which is difficult to separate from the concretions. Some examples suggest that the preservation of the fossils was restricted to the concretions and parts of the carcass may have been dissolved by rain water after fossilization (Gasparini and Iturralde-Vinent, 2006). Skulls can be fairly complete or fragmentary, due to the partial loss of the braincase or the tip of the rostrum. However, in many of the skulls the mandible is articulated although slightly twisted, *e.g.* *Vinialesaurus caroli*, *Gallardosaurus iturraldei*, and the rhacheosaurin crocodylomorphs (MNHNCU P3009 and USNM PAL 419640). This suggests that the missing part of those bones may have been originally preserved in the embedding shales, but were later lost due to weathering or a secondary erosion of the concretion by down slope movements or by farmers during land preparation (Gasparini and Iturralde-Vinent, 2006). Both saurian and fish elements can be found in association with ammonites encrustations and perforated by invertebrates (De la Torre y Callejas, 1949; Iturralde-Vinent and Norell, 1996; and author's observations) suggesting that some specimens suffered decay providing that the bones were eventually exposed and dispersed on the sea bottom prior to burial. Fish remains can be flattened, probably due to desiccation, but three-dimensional specimens also occur. They usually are not dismembered and retain their scales, suggesting that the bodies were not scavenged. The taphonomic analysis of reptilian bones suggests that there was no active predation on the sea floor prior to fossilization. (Gasparini and Iturralde-Vinent, 2006; Wierzbowski, 1976).

Tithonian strata are generally poor in vertebrate remains, although the well-stratified limestones of the Late Oxfordian (?) to Valanginian Guasasa and Artemisa Formations have yielded pectoral and caudal fins of *Hypsocormus*–like fish (Sánchez-Roig, 1920), a few fragmentary and undiagnostic marine reptile bones (Judoley and Furrazola-Bermúdez, 1965) and unidentified plesiosaurian remains (Furrazola-Bermúdez in Gasparini and Iturralde-Vinent, 2006). In latest Jurassic strata of the Artemisa Formation at Vega Nueva Quarry (Loc. 23, Fig. 2), a well preserved nearly complete fish specimen was found recently (E. Linares, *personal commun.*, 2013). Both Guasasa and Artemisa formations rest, respectively, on the Jagua and Francisco Oxfordian formations and represent two facies: carbonate shelf and slope deposits.

RESULTS AND DISCUSSION

To date, the fossil vertebrates found in the Late Jurassic rocks of western Cuba comprise more than five hundred fish and more than seventy reptilian specimens. The specimens are preserved in several collections (Table I). In Cuba, the Museo Nacional de Historia Natural has the largest and best documented collection, including some of the earliest specimens to be collected. Other materials in paleontological collections of this country have suffered from inadequate or no curation and in the course of our study we found some specimens that were only partly labeled or in unsatisfactory condition.

The following table lists the vertebrate taxa identified from Jurassic strata of Cordillera de Guaniguanico (Table II).

We re-examined and photographed the fossils in our Cuban collections and tentatively identified several fish specimens of Late Oxfordian age including *Gyrodus* sp. cf. *Gyrodus macrophthalmus cubensis* Gregory, 1923 (MNHNCu P0822, 2003, 2091, 2093, 2094, 2104, 2107, 2110, 2112, 3852, 3857, 3887, 3892, 5068, 5070, 5071, 5079, 5081); *Lepidotes* sp. (MNHNCu P2122, 3829, 5074); cf. *Luisichthys vinalesensis* White, 1942 (MNHNCu P0821, 2102, 2116, 3821, 3831, 5298); cf. *Caturidae* indet. (MNHNCu P2002); cf. *Pachycormidae* indet. (MNHNCu P3922); and *Pycnodontiformes* indet. (MNHNCu P5078). These species all came from the Jagua Formation. There are also fish material of Oxfordian age (also from the Jagua Formation) of *Lepidotes* Agassiz, 1832 (identified by D. Thies, *personal commun*., 2010), *Gyrodus* sp. and *Caturus* sp. in the paleontological collection of the Museo "Dos Hermanas" that have not been cataloged. Only a small specimen (IGP-V-273) stored at Instituto de Geología y Paleontología de Cuba, which we tentatively identified as leptolepid fish, probably came from the limestones of the Artemisa Formation (as it is labeled as collected in that unit). Thus, the diversity of actinopterygians appears to be higher in rocks of the Late Oxfordian Jagua Formation.

Unfortunately, the preserved fish material in the Cuban collections is mostly unprepared and therefore, some specimens could not be identified. *Gyrodus*–like is by far the most abundant element of the Cuban Jurassic fish assemblage demonstrating that these pycnodonts were abundant in the Caribbean Seaway's ecosystem.

A notable number of fish specimens housed in paleontological collections are pending identification. We have also found that some of the preliminary information shown on the labels in the collections is probably incorrect. For example, two unpublished fish taxa (*Gyrodus vinalensis* and *Lepidotes vinalensis* named by D.H. Dunkle in 1950) , based on specimens housed in the vertebrate paleontological collections of the Museum of Paleontology of University of California, are *nomen nudum* because have never been described. The specimen AMNH 8031 labeled as "*Colobodus*?, Jurassic, Constancia (?), Cuba, Acc. 260 from Dr. Carlos De la Torre", is the Turonian ptychodontid shark *Ptychodus cyclodontis* (Mutter *et al*., 2005). Likewise, some materials could not be located in the museums' collections (*e.g.* specimen MCZ 6500, J. Cundiff, *personal commun*., 2009; and specimen AMNH 2258, J. Maisey, *personal commun*., 2010).

Furthermore, as suggested by Schaeffer and Patterson (1984) and G. Arratia, *personal commun*. (2011), the validity of some published fish taxa is questionable, for example: *Caturus*, *Sauropsis* (?), *Eugnathides* and *Leptolepis sensu* Gregory (1923). White's (1942) monotypic "leptolepid" genus *Luisichthys* was placed within the family Varasichthyidae acoording to Arratia and Schultze (1985). Therefore, the Late Jurassic fish fauna of Cuba includes at least three valid species of Oxfordian age (*Lepidotes gloriae*, *Luisichthys vinalesensis*, and *Aspidorhynchus arawaki*).

Concerning reptilian taxa, various isolated saurian bones (MNHNCu P3002, P3003) stored at the Museo Nacional de Historia Natural de Cuba were named as *Cryptocleidus*? [*sic*] *vignalensis* by Ricardo de la Torre y Madrazo, another *nomen nudum* as it was never described (see Iturralde-Vinent and Norell, 1996: p. 11-12 for general comments), and the material is not adequate to be positively assigned to any taxa (Gasparini and Iturralde-Vinent, 2006). Many other elements recovered from the same stratigraphic horizon such as vertebrae, fragmentary mandibles, and pectoral girdles, are also present in the MNHNCu collection (Iturralde-Vinent and Norell, 1996). Such specimens were labeled by Z. Gasparini as Plesiosauroidea indet. (MNHNCu P3066, P3805, P3832) and Cryptoclididae indet. (MNHNCu P3005, P3006, P3804). Additional disarticulated bones, ribs, phalange, and vertebrae of marine reptiles housed at the Instituto de Geología y Paleontología de Cuba were catalogued as Plesiosauria (cf. *Cryptoclidus*? sp.), but the fragmentary nature of these specimens prevents a more precise identification than Plesiosauroidea indet. A three-dimensional plesiosaurian paddle (stored at the Fundación Antonio Núñez-Jiménez para la Naturaleza y el Hombre, unnumbered), although perhaps not taxonomically

Table II. Jurassic vertebrate taxa identified from Cordillera de Guaniguanico, western Cuba.

Taxa	Specimen number	References	Locality in figure 1	Annotation
REPTILES				
Camarasaurid sauropod	Lost	Salgado in Gasparini and Iturralde-Vinent (2006)	(10) Jagua Vieja	Originally identified as *Diplodocus* or *Brontosaurus* by De la Torre (1949)
Nesodactylus hesperius Colbert	AMNH 2000	Colbert (1969)	(13) Hoyo del Palmar	
Cacibupteryx caribensis Gasparini, Fernández and De la Fuente	IGP-V-208	Gasparini, Fernández and De la Fuente (2004)	(10) Jagua Vieja	
Gallardosaurus iturraldei Gasparini	MNHNCu P3005	Gasparini (2009)	(15) Caiguanabo	Previously identified as *Peloneustes* sp. *sensu* Gasparini and Iturralde-Vinent (2006)
Vinialesaurus caroli Gasparini, Bardet and Iturralde-Vinent	MNHNCu P3008	Gasparini, Bardet and Iturralde-Vinent (2002)	(2) Near Viñales	Previously identified as *Cryptocleidus cuervoi caroli* by De la Torre y Madrazo and Rojas (1949)
Ophthalmosaurid gen. and sp. indet.	MNHNCu P3068	Fernández and Iturralde-Vinent (2000), Gasparini and Iturralde-Vinent (2006)	(2) Near Viñales	
Ichthyosaur	MNHNCu P3001	De la Torre y Madrazo and Cuervo (1939), Gasparini and Iturralde-Vinent (2006)	(3) Laguna de Piedra (Norte)	Named as *Ichthyosaurus torrey* De la Torre y Madrazo and Cuervo, later Gasparini and Iturralde-Vinent referred to Ichthyosaur.
Caribemys oxfordiensis De la Fuente and Iturralde-Vinent	MNHNCu P3125	De la Fuente and Iturralde-Vinent (2000)	(2) Near Viñales	
Cricosaurus sp.	MNHNCu P3009	Gasparini and Iturralde-Vinent (2001)	(1 to 3) Southern slope of Sierra de Guasasa	This taxa is in need of revision
Cricosaurus sp.	USNM PAL 419640	Gasparini and Iturralde-Vinent (2001)	(1) Puerta de Ancón	Previously assigned to Cryptocleidoid by O'Keefe and Wahl (2003). This taxa is in need of revision
Thalattosuchia indet.	USNM PAL 451942	Gasparini and Iturralde-Vinent (2006)	(14) Hoyo de la Sierra	
FISH				
Taxa	**Specimen number**	**References**	**Locality in figure 1**	**Annotation**
Aspidorhynchus arawaki Brito	USNM PAL 018648	Brito (1997, 1999)	Specific locality of this specimen unknown	
Caturus deani Gregory	AMNH 7930	Gregory (1923)	(2) Near Viñales	This taxa is in need of revision
Eugnathides browni Gregory	AMNH 7937	Gregory (1923)	(9) Mogote La Mina	This taxa is in need of revision
Gyrodus macrophthalmus cubensis Gregory	AMNH 7928	Gregory (1923)	(9) Mogote La Mina	
Hypsocormus leedsi	NMH P.13090		(4) Laguna de Piedra (Sur)	This taxa is in need of revision
Lepidotes gloriae Thies	USNM PAL 279856	Thies (1989)	Specific locality of this specimen unknown, but probably (14) Hoyo de la Sierra	
Leptolepis euspondylus Gregory	AMNH 7939	Gregory (1923)	(9) Mogote La Mina	This taxa is in need of revision
Luisichthys vinalesensis White	MCZ 8345	White (1942), Arratia and Schultze (1985)	Specific locality of this specimen unknown	
Sauropsis woodwardi Gregory	AMNH PAL 7934	Gregory (1923)	(2) Near Viñales	This taxa is in need of revision

important, it is the only occurrence of a well-preserved paddle for Cuban Late Jurassic marine reptiles.

The only marine turtle specimen found in the Cuban Oxfordian was named *Caribemys oxfordiensis* by De la Fuente and Iturralde-Vinent (2001), who recognized its relationships to other pleurodiran turtles from the Late Jurassic. More recently, Cadena-Rueda and Gaffney (2005) recombined the Cuban turtle to *Notoemys oxfordiensis*. De Lapparent de Broin *et al*. (2007), however, keeps *Caribemys oxfordiensis* within the family Notoemydidae.

Marine crocodilians are represented by three specimens (MNHNCu P3009, USNM PAL 451942, 419640). The MNHNCu P3009 specimen was assigned to *Geosaurus* sp. by Gasparini and Iturralde-Vinent (2001), but later transferred to its early synonym *Cricosaurus* (Young and Andrade, 2009). The USNM PAL 419640 specimen was preliminarily identified as plesiosaur (Iturralde-Vinent and Norell, 1996: p. 11), later referred to *Geosaurus* sp. (Gasparini and Iturralde-Vinent, 2001), but can also be related to *Cricosaurus*. Neither of these papers provided a detailed description for the specimen, which is acid prepared and partially melted in the process, loosing important bone features (note that in both papers USNM PAL 419640 was referred to as USNM 18699). On the other hand, O'Keefe and Wahl (2003, fig. 6) provided a brief description but incorrectly interpreted USNM PAL 419640 as an aberrant cryptocleidoid plesiosaur. More recently, Gasparini and Iturralde-Vinent (2006) and Young and Andrade (2009) identified the specimen as an indeterminate metriorhynchine.

Gasparini and Iturralde-Vinent (2001) included a fragmentary skull (MNHNCu P3001) in Metriorhynchidae, but it has subsequently been re-assessed to be an ichthyosaur (Gasparini and Iturralde-Vinent, 2006). This specimen is quite remarkable since not many three-dimensional Late Jurassic ichthyosaurian skulls are known (Z. Gasparini, *personal commun*., 2010). Only MNHNCu P3068 was properly identified as ichthyosaur (Fernández and Iturralde-Vinent 2000), probably an Ophthalmosauridae.

Another fossil misidentified as Ichthyosauridae (*Sphaerodontes caroli* De la Torre y Madrazo and Cuervo, 1939), was a negative spheroidal cast which was later tentatively identified by Iturralde-Vinent and Norell (1996: p. 12) as a ganoid fish tooth. Iturralde-Vinent and Norell (1996: p. 12) also listed a set of four plesiosaurian elements collected by Charles W. Hatten in 1956 from a locality about one kilometer southwest of the town of Viñales, and stored in the Berkeley's Museum of Paleontology, but these specimens are now lost (M. Goodwin, *personal commun*., 2009). According to Furrazola-Bermúdez (*fide* Iturralde-Vinent and Norell 1996), a large carcass of a *Plesiosaur*–like marine reptile was found in Tithonian limestones of the El Americano Member (Guasasa Formation) in the locality named "Hacienda del Americano", but apparently was lost due to quarry exploitation. In 1972, a Tithonian reptilian bone fragment collected in the Niceto Pérez area (Rancho Mundito) was given to Dr. Alfredo de la Torre y Callejas for identification (A. Pszczólkowski, *personal commun*., 2009), but it whereabouts is currently unknown. Furthermore, during the geological mapping carried out in the Pinar del Rio province in the mid-seventies, vertebrate remains were observed in the Tithonian limestones of La Zarza Member of Artemisa Formation, however, because they were incomplete, none of these materials ended in museum's collections (A. Pszczólkowski, *personal commun*., 2009). These findings indicate that the Tithonian strata may also be an important source of fossil marine reptiles that have yet to be properly collected and identified.

Within the collections, flying reptiles (pterosaurs) are represented by two remarkable rhamphorhynchoid specimens: *Nesodactylus hesperius* (AMNH 2000) and *Cacibupteryx caribensis* (IGP-V-208), which is the best preserved Middle-Late Oxfordian pterosaur skull reported so far (Gasparini *et al*., 2004). A third probable pterosaur specimen (MNHNCu P3806) preserved on the surface of a partially eroded concretion was discovered (during a paleontological survey directed by the senior author) at the beginning of 2002. An extremely fragmented pterosaur remains (MNHNCu P3817) was collected from a poorly identified locality in Sierra de los Órganos. A fragment of mandible with long pointed, recurved teeth (MNHNCu P3794) can provisionally be referred to as pterosaur. These fossils collectively indicate a high potential of finding more pterosaur remains in the Oxfordian sediments of the Jagua Formation.

Dinosaur material was not found in any Cuban vertebrate collection, neither discovered during field work performed since 1998. Only Gutiérrez (1981) reported the discovery of two dinosaurian bones from Punta de la Sierra, Pinar del Rio province, but they are lost. Unpublished photographs provided by R. Gutiérrez (*personal commun*., 2010) add no clue, as the suspected bones are not identifiable.

Early in the 20th century a 45-centimeter long bone of a sauropod dinosaur was collected by Carlos de la Torre y Huerta from the Jagua Vieja Member of Jagua Formation. De la Torre y Callejas (1949) described and identified the element as a femur or humerus of '*Diplodocus*' or '*Brontosaurus*' with their "extremes missing". This historical specimen unfortunately got lost, but based on De la Torre y Callejas' description and illustration, L. Salgado (in Gasparini and Iturralde-Vinent, 2006) identified the element as a fairly complete metacarpal bone of a camarasauromorph dinosaur, common in the Late Jurassic of North America.

Oxfordian vertebrate fossils in western Cuba are fairly common in the Jagua Vieja Member of Jagua Formation. While many specimens have been collected from these rocks, some of the fossil-bearing concretions in the museums remain unprepared, so more fossil evidence is sure to be recovered in the future. The Tithonian beds also represent a challenge for further collecting.

CONCLUSIONS

The Late Jurassic rocks in Cuba have produced a reach vertebrate assemblage dominated by actinopterygians and long-necked plesiosaurs. There are also pliosaurs, metriorhynchid crocodilians, pleurodiran turtles, ichthyosaurs, pterosaurs, and sauropod dinosaurs. Fish assemblages include pycnodontiforms, semionotiforms, amiiforms, pachycormiforms, aspidorhynchiforms, pholidophoriforms, and smaller leptolepids. Abundant terrestrial plant remains, yet unidentified, as well as marine invertebrates have been recovered from the same beds. Although the richest reptile-bearing horizons are found within the Oxfordian Jagua Formation, which has produced more than six hundred vertebrate specimens, the unidentified fossil vertebrates encountered in Tithonian strata demonstrate that more collecting is needed within this stratigraphic horizon. Up to the present, the western territory of Cuba is the only place in the Caribbean islands which yields mid-to early-Late Oxfordian and Tithonian vertebrates. Fish are fairly well preserved, but reptilian specimens usually suffered decay and the bones were eventually exposed and dispersed in the sea bottom prior to burial.

The Cuban Late Jurassic vertebrate material is dispersed in paleontological collections of Cuba, Puerto Rico, the United States of America, and England. Many specimens are fossil fragments that were collected in the early 20th century and have only been formally described in the last decade. Today, Cuban Late Jurassic vertebrates are best known, but research must continue, especially in the Tithonian strata.

Advances in our understanding of Late Jurassic fossil-bearing localities in Cuba and the recent improvement of taxa identification are summarized, and a list of specimens is included as Appendix 2.

In summary, the review of the historical collections confirms that: (1) the western Cuban Oxfordian material is of worldwide importance; (2) actinopterygians and marine reptiles prevail in the vertebrate faunal composition; (3) some fossils are preserved in great detail, especially fish and pterosaurs; (4) some fish taxa remain obscure and must be investigated in the future; (4) this assemblage of vertebrate fossils has shed light in understanding the marine fauna circulating across the Late Jurassic Caribbean Seaway; (5) future research is necessary because there is abundant unprepared material in the museums and in the field, pending to be prepared and investigated.

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APPENDIX 1

Annotated list of the known Cuban Late Jurassic collecting sites arranged in the same order that they are numbered in Figure 2. Data included with the list were the location, stratigraphic level and a synopsis of the scientific potential of each site, ranging from sites with multiple findings to those with a single one.

1 **Loc. Puerta del Ancón** (Iturralde-Vinent and Norell, 1996: p. 11).

Location. Sheet Consolación del Sur, coordinates: x 221,100 y 316,000. Jagua Formation. The fossils are from the southern and southwestern slope of the hills.

Vertebrate fauna. This locality has yielded *Luisichthys vinalesensis* (MCZ 8344), indeterminate fish (IGP-V-278), and rhacheosaurin metriorhynchid (USNM PAL 419640).

2 **Loc. "Near Viñales"** (Iturralde-Vinent and Norell, 1996: p. 7).

Location. Ambiguous locality probably referred to the southern slope of Sierra de Guasasa, on the northern flank of the Viñales valley, northeast of the town of Viñales. Jagua Formation.

Vertebrate fauna. Type locality for plesiosaur *Vinialesaurus caroli* (MNHNCu P3008). Other remains include the type material of *Cryptocleidus*? [*sic*] *cuervoi* (De la Torre y Madrazo and Rojas, 1949) which is *nomen dubium*; rhacheosaurin metriorhynchid (MNHNCu P3009), ophthalmosaurian ichthyosaur (MNHNCu P3068) and few plesiosauroids (MNHNCu P3007, 3065, 3066, 3070).

3 **Loc. Laguna de Piedra (Norte)** (Iturralde-Vinent and Norell, 1996: p. 11).

Location. Sheet Consolación del Sur, coordinates: x 222,900 y 316,300. Jagua Formation. This locality corresponds to the southern slope of the Sierra de Guasasa, a few kilometers east of Puerta del Ancón.

Vertebrate fauna. Fossil vertebrates collected here since early 20th century include the unpublished taxa *Cryptocleidus?* [*sic*] *vignalensis* (MNHNCu P3002, 3003), an unidentified ichthyosaur (MNHNCu P3001) designated as the holotype of *Ichthyosaurus torrey* (De la Torre and Cuervo, 1939), and the material designated as the holotype of *Sphaerodontes caroli* (De la Torre and Cuervo, 1939), all of them are *nomen dubium*. Fish remains collected more recently include a tail of probable caturid fish (MNHNCu P2002).

4 **Loc. Laguna de Piedra (Sur)** (Judoley and Furrazola-Bermúdez, 1965; Sánchez-Roig, 1920).

Location. Although this locality is reported as Tithonian in age from the literature, according to J. Gallardo, Jr. (*personal commun.*, 2010) it is probably the unpublished Oxfordian locality known as "La Chorrera", which contains fossil-bearing concretions.

Vertebrate fauna. Caudal fins and disarticulated bones of fish (NMH P.13089, 13090, 13091, 13092) provisionally identified as *Hypsocormus* and labeled as Tithonian in age.

5 **Loc. Mogote la Penitencia**

Location. Sheet Consolación del Sur, coordinates: x 217,500 y 314,000. Described as Jurassic. Jagua Formation (?).

Vertebrate fauna. According to J. Gallardo, Jr. (*personal commun.*, 2010) this locality contains vertebrate fossils, however, only a single record appears in the collections (MCZ 12490).

6 **Loc. Valle los Jazmines**

Location. This is an ambiguous locality. Sheet Consolación del Sur. Described as Oxfordian. Jagua Formation (?).

Vertebrate fauna. It has yielded fish *Caturus* sp. (MCZ 10484, 10485).

7 **Loc. Viñales Town** (Iturralde-Vinent and Norell, 1996: p. 12).

Location. Sheet Consolación del Sur, coordinates: x 220,800 y 310,900. About 1 km SW of the town of Viñales. Jagua Formation.

Vertebrate fauna. Very fragmentary bones of indeterminate plesiosaurs (UCMP 105703, 105704, 105720, 105725). We recently visited this locality and no fossils are currently exposed at this site.

8 **Loc. Hoyo de San Antonio** (Iturralde-Vinent and Norell, 1996: p. 12).

Location. Sheet La Palma, coordinates: x 226,300 y 320,800. The Jagua Formation outcrops in low hills and in the valley.

Vertebrate fauna. Indeterminate pterosauroid (MNHNCu P3806), pliosauroid (MNHNCu P0828) and plesiosaurian bones (MNHNCu P3805, USNM PAL 18688, 18721), cryptoclidid mandible (MNHNCu P3806), and Ichthyosauria indet. (MNHNCu P3808). Source of abundant and diverse fish fauna: *Gyrodus macrophthalmus cubensis* (MCZ 6639, 6640), *Gyrodus* sp. (MCZ 10377, 10389, 10390, 10416), *Caturus deani* (MCZ 6641, 8352), *Caturus* sp. (MCZ 10394, and other 16 MCZ specimens), *Hypsocormus* sp. (MCZ 10247, 10248, 10250, 10238), *Lepidotes* sp. (MCZ 10300, 10301, 10302, 10303), cf. *Pachycormidae* indet. (MNHNCu P3922), and several unidentified fish specimens (e.g. MNHNCu P0796, 0810, 0814, 0828, 0838, 1971, 3125, 3794, 3796, 3798, 3799, 3800, 3801, 3804, 3805, 3806, 3819, 3820, 3824, 3825, 3826, 3829, 3831, 3833, 3834, 3839, 3840, 3842, 3843, 3844, 3845, 3846, 3847, 3848, 3850, 3852, 3853, 3855, 3870, 3904, 3921, 3922, 5082, 5103, 5297, 5108, 5162). Type locality for turtle *Caribemys oxfordiensis* (MNHNCu P3125). We recently visited this locality with Juan Gallardo, Jr., and still is rich in fossil-bearing concretions.

9 **Loc. Mogote La Mina** (Iturralde-Vinent and Norell, 1996: p. 14).

Location. Represented by the south slope of Mogote La Mina, located just south of the old copper mine. The mine itself is not a fossil-bearing site as no Oxfordian sediments are present. Sheet La Palma, coordinates: x 226,300 y 320,800. Jagua Formation.

Vertebrate fauna. This locality has yielded *Gyrodus macrophthalmus* (AMNH 7927), *Leptolepis*? *euspondylus* (AMNH 7939), *Eugnathides browni* (IGP-V-291) and marine reptiles (Brown and O'Connell, 1922).

10 **Loc. Jagua Vieja** (Iturralde-Vinent and Norell, 1996: p. 12). This is the Cuban richest Late Jurassic vertebrate locality.

Location. Sheet La Palma, coordinates: x 228,800 y 320,900. Jagua Formation. Slopes of mogote Jagua Vieja.

Vertebrate fauna. Type locality for pterosaur *Cacibupteryx caribensis* (IGP-V-208). One of few pterosaur localities in western Cuba. Also, historically important site as it has yielded a sauropod bone (De la Torre y Callejas, 1949). Some plesiosaurian remains (IGP-V-209, 210, 211, 258, 259) and other indeterminate reptilian bones (IGP-V-212, 213). Diverse fish fauna including *Gyrodus macrophthalmus cubensis* (MCZ 6638, 6646, 6647, 6648), *Gyrodus* sp. (MCZ 10380, and other MCZ specimens), *Gyrodus* cf. *macrophthalmus cubensis* (MNHNCu P2111, 2112, 3857, IGP-V-280), *Eugnathides browni* (MCZ 6649), *Caturus deani* (MCZ 6637, 6642, 6643, 6644, 6645, 6500), *Caturus* sp. (MCZ 10492, and other MCZ specimens), *Hypsocormus leedsi* (MCZ 7023, 7024, 7024), *Hypsocormus* sp. (MCZ 10229, and other MCZ specimens), *Lepidotes* sp. (MNHNCu P5074, MCZ 10290, and other MCZ specimens), *Luisichthys vinalesensis* (MCZ 8345, 8346, 8347, 8348), cf. *Luisichthys vinalesensis* (MNHNCu P0821, 2116), leptolepid (IGP-V-283) and Pycnodontiformes indet. (MNHNCu P5078). Numerous unidentified fish specimens (*e.g.* MNHNCu P0834, 2123, 3807, 3818, 3823, 3838, 3856, 3863, 3864, 3877, 3878, 3886, 3892, 5069, 5080, 5085, 5091, IGP-V-243, 244, 245, 251, 268, 269, 270, 271, 272, 275, 276, 277, 279, 284, 285, 286, 287, 292).

11 **Loc. Hacienda El Americano** (Iturralde-Vinent and Norell, 1996: p. 14).

Location: Sheet La Palma, coordinates: x 240,300 y 321,400. Outcrops of the Tithonian El Americano Member of Guasasa Formation are found north and northeast of the "bungalow".

Vertebrate fauna: Skull and fragmentary skeleton of a marine reptile destroyed during mining operation (Furrazola-Bermúdez in Gasparini and Iturralde-Vinent, 2006). Scattered fish imprints and vertebrae (Pszczólkowski and Myczyński, 2010).

12 **Loc. Mogote Pico Chico**

Location. Sheet La Palma, coordinates: x 342,400 y 321,300. Described as Oxfordian "Camada de Quesso" [*sic*]. Jagua Vieja Member of the Jagua Formation (?).

Vertebrate fauna. This locality has yielded *Gyrodus* sp. (MCZ 10417, 10418, 10425, 10426), *Hypsocormus* sp. (MCZ 10243), *Hypsocormus leedsi* (MCZ 7013, 7014, 7015, 7016), and *Caturus deani* (MCZ 8329).

13 **Loc. Hoyo del Palmar** (Iturralde-Vinent and Norell, 1996: p. 13).

Location. Sheet La Palma, coordinates: x 227,800 y 321,000. The Jagua Formation outcrops on the slopes of a small valley.

Vertebrate fauna. The locality was visited by Iturralde-Vinent and Norell (1996: p. 13) and very fragmentary bones of marine reptiles were observed. Furthermore, because it is the probable source of the pterosaur *Nesodactylus hesperius* (AMNH 2000), this is an important paleontological site. Vertebrate fauna also include the reptiles (MNHNCu P3883), cf. *Luisichthys vinalesensis* (MNHNCu P2102), *Gyrodus* cf. *Gyrodus macrophthalmus cubensis* (MNHNCu P2104, 2107), and other indeterminate forms (MNHNCu P2103, 2124, 2125, 2129, 3883, 5044, 5084).

14 **Loc. Hoyo de la Sierra** (Iturralde-Vinent and Norell, 1996: p. 13).

Location. Sheet Herradura, coordinates: x 243,550 y 316,800. The locality is along the slope surrounding the small valley. Jagua Formation.

Vertebrate fauna. Plesiosaur mandible (MNHNCu P3069), indeterminate plesiosaurian bones (USNM PAL 18712) and several fish (MNHNCu P3872, 3884, 5073, 5075, 5076, 5077, 5083, 3067, 3907, 5307, 5308), *Gyrodus* cf. *Gyrodus macrophthalmus cubensis* (MNHNCu P5070, 5071, 5079, 5081).

15 **Loc. Caiguanabo** (Iturralde-Vinent and Norell, 1996: p. 12).

Location. Sheet Herradura, coordinates: x 244,200 y 316,900. Northern slope of the Sierra de Caiguanabo. Jagua Formation.

Vertebrate fauna. Type locality for pliosaur *Gallardosaurus iturraldei* (MNHNCu P3005). Abundant isolated indeterminate reptile bones (IGP-V-252, 254, 255, 256, 257, 264). Plesiosaur femur (MNHNCu P3004) and plesiosaur remains identified as *Cryptocleidus*? [*sic*] (IGP-V-248). Fish remains identified as *Gyrodus* cf. *Gyrodus macrophthalmus cubensis* (MNHNCu P2091, 2093, 2094), *Gyrodus macrophthalmus* (IGP-V-242) and *Lepidotes* sp. (MNHNCu P2122). Several unidentified fish specimens (*e.g.* MNHNCu P2090, 2092, 2099, 2100, 2101, 2106, 2113, 2117, 2120, 5104, IGP-V-246, 281).

16 **Loc. Niceto Pérez (Rancho Mundito)** (A. Pszczólkowski, *personal commun.*, 2009).

Location. Sheet San Cristobal, coordinates: x 370,500 y 324,500. Black Tithonian limestones of La Zarza Member, Artemisa Formation.

Vertebrate fauna. An unidentified reptilian bone fragment now lost.

17 **Loc. Rangel Arriba**

Location. Sheet San Cristobal, coordinates: x 275,600 y 326,500. Described as Jurassic. Jagua Formation (?).

Vertebrate fauna. Only a single unidentified record appears in collections (MCZ 12487).

18 **Loc. Puerta de la Muralla** (Iturralde-Vinent and Norell, 1996: p. 15).

Location. Sheet San Cristobal, coordinates: x 284,600 y 325,300. Outcrops of the Late Oxfordian to Lower Cretaceous Artemisa Formation. Sierra del Rosario, NW of San Cristobal, along the road known as "Camino de Cinco Pesos".

Vertebrate fauna. This site yielded a fragmentary plesiosaur limb girdle (MNHNCu P3006) and plesiosaurian bone (IGP-V-263).

19 **Loc. "No 2 near Cinco Pesos"** (Kutek *et al.*, 1976: p. 301).

Location. Coordinates: x 282,550 y 328,650. Francisco Formation.

Vertebrate fauna. Fish remains are frequently noted at this locality in the stratigraphic description of the Francisco Formation (Kutek *et al.*, 1976; Pszczólkowski, 1978, 1999), but no taxa have thus far been identified.

20 **Loc. "1 km N of Cinco Pesos"** (Kutek *et al.*, 1976: p. 303).

Location. Coordinates: x 282,100 y 328,800. Francisco Formation. The exposure is situated in the NE escarpment of the road, 500 m W of the locality No 2.

Vertebrate fauna. The limestones yield badly preserved ammonites, as well as fish fragments.

21 **Loc. Punta de la Sierra** (Iturralde-Vinent and Norell, 1996: p. 14).

Location. Sheet San Juán y Martínez, coordinates: x 191,500 y 280,000. Jagua Formation. Isolated blocks of limestone in a small river.

Vertebrate fauna. Two alleged "large reptilian bone fragments", now lost (Gutiérrez, 1981), probably epidiagenetic siliceous aggregates.

22 **Loc. "Finca Grau, near La Palma"** (Iturralde-Vinent and Norell, 1996: p. 15).

Location. Precise locality unknown. Described as Jagua Formation.

Vertebrate fauna. Indeterminate plesiosaurian bones (USNM PAL 18697).

23 **Loc. "Vega Nueva"** (E. Linares, *personal commun.*, 2013).

Location. Vega Nueva quarry, west of La Palma. Artemisa Formation.

Vertebrate fauna. A single fossil fish specimen about 20 centimeters long with very well preserved vertebrae.