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Permian reptilian fauna from the Kundaram Formation, Pranhita-Godavari Valley, India

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ABSTRACT—The Kundaram Formation of the Pranhita-Godavari Valley yields the only Permian reptilian fauna in India. It is composed essentially of a dicynodont assemblage and includes *Endothiodon, Cistecephalus, Pristerodon, Oudenodon* and *Emydops*-like forms. The only non-dicynodont member is a captorhinid reptile. These taxa allow the correlation of the Kundaram Formation with the *Tropidostoma* and/or *Cistecephalus* Assemblage Zones of the Beaufort Group of South Africa, the basal beds of Madumabisa Mudstones of Zambia, the Ruhuhu and lower part of the Kawinga Formation of Tanzania and the Morro Pelado member of the Rio do Rasto Formation of Brazil, indicating a Late Permian (Tatarian) age. The Kundaram fauna helps in fixing the upper age of the coal-bearing Damuda Group more precisely at Tatarian. The distribution of the Late Permian dicynodonts in the now widely separated geographic areas suggests the close proximity of the continents and a lack of endemism or provinciality.

RÉSUMÉ—La Formation de Kundaram de la vallée de Pranhita-Godavari renferme la seule faune reptilienne permienne d'Inde. Elle est essentiellement composée d'une association de dycinodontes comprenant les genres *Endothiodon, Cistecephalus, Pristerodon*, des *Oudenodon* et des formes de type *Emydops*. Le seul membre non-dicynodontes est un captorhinide. Ces taxa permettent la corrélation de la Formation de Kundaram avec les Zones d'assemblage à *Tropidostoma* et/ou *Cistecephalus* du Groupe de Beaufort en Afrique du Sud, des niveaux de la base des Argiles de Madumabisa en Zambie, de la Formation de Ruhuhu et de la partie inférieure de la formation de Kawinga en Tanzanie et du Membre de Morro Pelado de la Formation du Rio do Rasto au Brésil, ce qui indique un âge Permien supérieur (Tatarien). La faune de Kundaram concourt à fixer un âge minimum Tatarien au Groupe charbonneux de Damuda. La distribution des dicynodontes du Permien supérieur dans des régions actuellement très éloignées suggère une grande proximité des continents concernés et une absence d'endémisme ou de provincialisme.

INTRODUCTION

The Permian in India has a very poor representation in terms of vertebrate fauna. Permian vertebrate fossils are known only from two widely separated regions. These are the Tethyan Himalayan Belt in the north and in the peninsular part in the south. In these regions the vertebrate faunas of Late Permian age are dominated by palæoniscoid fishes (Woodward, 1905: Werneburg and Schneider, 1996) and temnospondyl amphibians (Lydekker, 1885: Tripathi, 1962: Werneburg and Schneider, 1996).

The only reptilian fauna of Permian age is known from the lower part of the Gondwana sucession in the northwestern part of the Pranhita-Godavari Valley (Kutty, 1972), one of the major Gondwana basins in Peninsular India (Fig. 1). This fauna, essentially a dicynodont assemblage, is restricted to the Kundaram Formation (Ray, 1997) near the village of Golet, Adilabad district, Andhra Pradesh. This paper deals with some aspects of the Kundaram fauna.

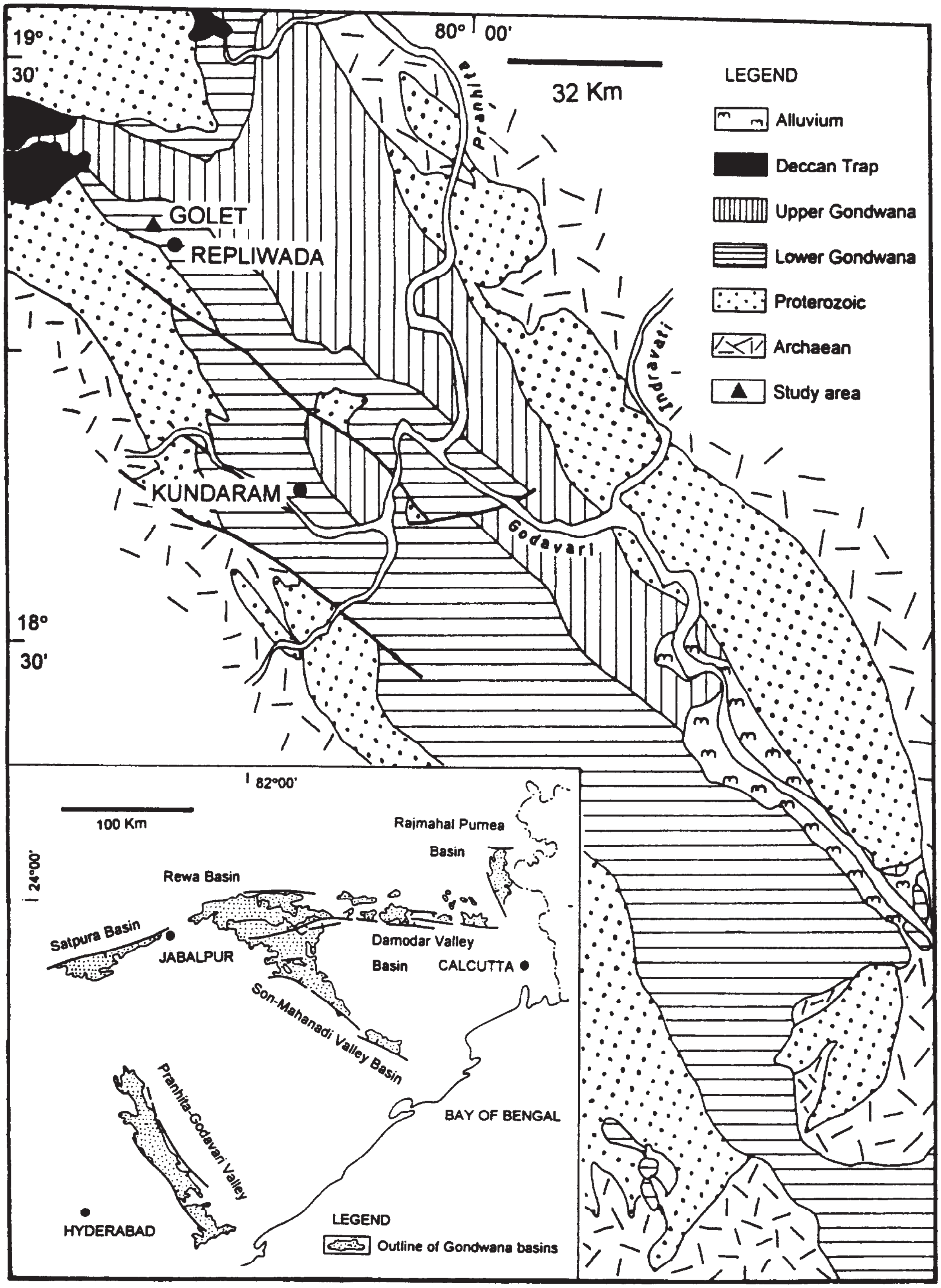

Figure 1. *Geological map of the Pranhita-Godavari Valley, India (after King, 1881) showing the study area near Golet. Inset: Major Gondwana basins of Peninsular India.*

Table 1. Permian stratigraphy of the Pranhita-Godavari Valley (after Kutty *et al.*, 1987; Bose and Sengupta, 1993; Ray, 1997)

<table>
<tr><th colspan="2">Formations</th><th>Main Lithologies</th><th>Important Fossils</th><th colspan="2">Age</th></tr>
<tr><td rowspan="2">Kamthi</td><td>Middle</td><td rowspan="2">Sandstone and siltstone</td><td rowspan="2">Glossopteris flora, ?dicynodont</td><td colspan="2">TRIASSIC</td></tr>
<tr><td>Lower</td><td rowspan="2">late Late</td><td rowspan="4">PERMIAN</td></tr>
<tr><td colspan="2">Kundaram</td><td>Mudstone, sandstone and ferruginous shale</td><td>dicynodonts captorhinid</td></tr>
<tr><td colspan="2">Barakar</td><td>Sandstone, carbonaceous shale and coal</td><td rowspan="2">Glossopteris flora</td><td>early Late</td></tr>
<tr><td colspan="2">Talchir</td><td>Tillite, greenish shale and sandstone</td><td>early Early</td></tr>
</table>

GEOLOGICAL BACKGROUND

The Pranhita-Godavari Valley (Fig. 1) represents one of the most complete and well-developed Gondwana rock successions in India. During the last few decades, work in the Pranhita-Godavari Valley has led to the discovery of various vertebrate fossils, mainly from Triassic and Jurassic sediments, indicating that the upper part of the Gondwana succession is richly fossiliferous in comparison to the lower part. This uneven picture of the faunal content reflects the Indian Gondwana basins from where prolific Pre-Triassic vertebrate fossils are yet to be reported.

The depositional history of the Gondwana rocks in the Pranhita-Godavari Valley began during the Early Permian with the deposition of the fluvioglacial Talchir Formation (Table 1). This is overlain by the coal-bearing fluviatile sediments of the Barakar Formation, which in turn is succeeded by the Kundaram Formation. The latter is characterised by the presence of red mudstone, sandstone, sandstone-mudstone alternations and ferruginous shale (Ray, 1997) deposited in river channels. The Kundaram Formation is in turn overlain by the Kamthi Formation.

THE PERMIAN VERTEBRATES OF THE PRANHITA-GODAVARI VALLEY

As in other Gondwana basins, Permian rocks of the Pranhita-Godavari Valley are characterised by the *Glossopteris* flora (Pascoe, 1959; Robinson, 1970). The only reptiles of Permian age in India have been collected from this basin. The fossils are mostly encrusted with a hard Fe matrix forming ferruginous oblate and spherical nodules. These are collected *in situ* as isolated skulls, cranial fragments and a few post cranial elements.

The fauna is composed of small- to medium-sized dicynodonts, largely represented by *Endothiodon uniseries* and a new *Endothiodon* species which includes two nearly complete skulls, several snouts and fragments of skulls and lower jaws amounting to about 30 individuals. The *Endothiodon* skull is distinguished by its triangular outline and a tapering snout, which bears prominent, longitudinal ridges. The intertemporal bar is quite narrow in comparison to a broad interorbital region. A large pineal foramen, bordered anteriorly by the preparietal and situated on a boss, is located centrally on the intertemporal bar. The premaxilla and maxilla together bear a single row of teeth.

Other dicynodont taxa include *Cistecephalus, Oudenodon, Pristerodon* and *Emydops*-like forms. There are two partial skulls of *Cistecephalus*, one with an associated lower jaw. Its skull is very broad and bears a very short and narrow snout. Small, slightly distorted skulls with attached lower jaws can be identified as closely related with *Emydops*. These skulls bear wide interorbital and intertemporal regions with exposed parietals and a circular pineal foramen. There is also a single specimen of *Pristerodon* (King, 1992). The posterior part of a medium-sized skull is identified as belonging to *Oudenodon*. It is characterised by a broad intertemporal bar with postorbitals overlapping and bounding the parietals laterally and by a large elliptical pineal foramen. The only non-dicynodont member of the Kundaram fauna is a small captorhinid reptile (Kutty, 1972) with a skull

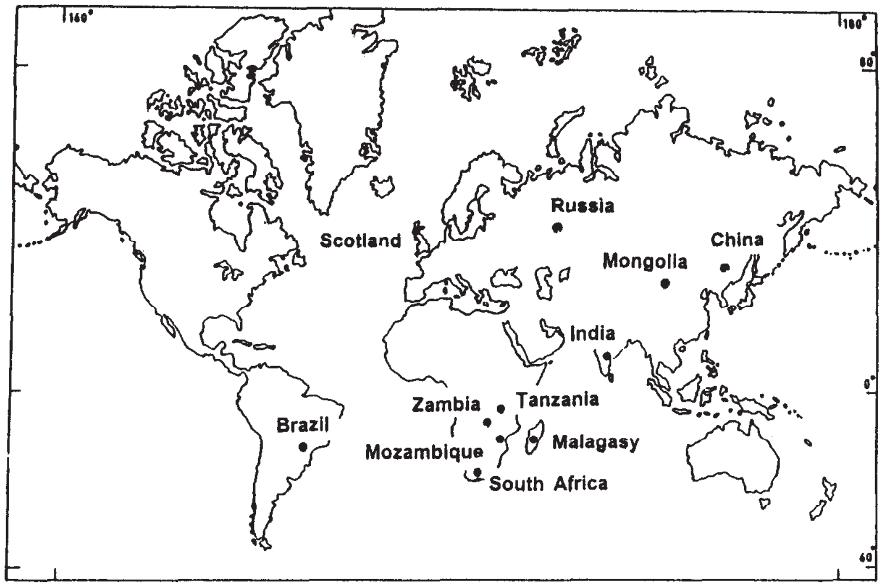

Figure 2. Late Permian dicynodont-bearing sediments of the world.

Table 2. The ranges of the dicynodont taxa present in the three assemblage zones of the Late Permian part of the Beaufort Group, Karoo Supergroup, South Africa (after Rubidge, 1995)

TEEKLOOF			**FORMATION**	
POORTJIE	**HOEDEMAKER**	**OUKLOOF**	**MEMBER**	
– – –	——	——	*Endothiodon*	D
——	——	——	*Pristerodon*	I
	——		*Tropidostoma*	C
	——	——	*Emydops*	Y
	– – – ——	——	*Rhachiocephalus*	N
	– – ——	——	*Cistecephalus*	O
——	——	——	*Diictodon*	D
	——		*Aulacephalodon*	O
	——	——	*Oudenodon*	N
	– – – –	——	*Dinanomodon*	T
	– – –	——	*Dicynodon*	I
				A
Pristerognathus	***Tropidostoma***	***Cistecephalus***	ASSEMBLAGE ZONE	

length of about 47 mm.

A small reptile was reported from the very hard siltstone unit of the overlying Kamthi Formation (Ramanamurthy and Rao, 1987). Though the skull is badly damaged, part of the squamosal is visible. Also preserved is a complete vertebral column with

Table 3. A correlation of the Kundaram Formation with other *Endothiodon*-bearing deposits

<table>
<tr><th></th><th colspan="2">South Africa</th><th>India</th><th colspan="2">South America</th><th>Zambia</th><th>Tanzania</th><th>Other Localities</th></tr>
<tr><td rowspan="7">LATE PERMIAN</td><td rowspan="6">LOWER BEAUFORT</td><td>Dicynodon</td><td rowspan="7">KUNDARAM*</td><td rowspan="4">RIO DO RASTO</td><td rowspan="2">MORRO PELADO*</td><td rowspan="7">MADUMABISA MUDSTONES*</td><td>KAWINGA (K6)*</td><td rowspan="7">England (CUTTIES' HILLOCK) Madagascar (LOWER SAKAMENA FORMATION) China and Mozambique*</td></tr>
<tr><td>Cistecephalus*</td><td rowspan="6">RUHUHU (K5)*</td></tr>
<tr><td>Tropidostoma*</td><td rowspan="2">SERRINHA</td></tr>
<tr><td>Pristerognathus*</td></tr>
<tr><td>Tapinocephalus</td><td colspan="2" rowspan="3"></td></tr>
<tr><td>Eodicynodon</td></tr>
<tr><td colspan="2">ECCA</td></tr>
</table>

Endothiodon-bearing horizons are marked by an asterix (*). Sources: Drysdall and Kitching (1963), Kutty (1972), Anderson and Cruickshank (1978), Barberena *et al.* (1985), Barberena and Araujo-Barberena (1991), King (1990, 1992), Rubidge (1995), King and Jenkins (1997) and Ray (1997).

the ribcage, the pectoral and pelvic girdles, and limb bones. The total length of the skeleton is about 395 mm and was tentatively identified as a ?dicynodont.

DISCUSSION

Although the Kundaram Formation is a newly designated member of the Gondwana succession of India and the study of its fauna is far from completion, it is of stratigraphical significance as it contains the only Late Permian dicynodont fauna from India. The Late Permian dicynodont-bearing horizons of the world are restricted mostly to the southern hemisphere (Fig. 2), except for their occurrences in China, Mongolia, Russia and Scotland. Apart from India, *Endothiodon* is known from Africa (South Africa, Zambia, Mozambique and Tanzania) and South America (Brazil). These *Endothiodon*-bearing regions are treated separately to draw a probable correlation of these horizons with the Kundaram Formation.

The most complete vertebrate record of the Late Permian period is found in the lower part of the highly fossiliferous Beaufort Group of the Karoo Supergroup, South Africa, and is subdivided into six biozones. *Endothiodon* appears first in the *Pristerognathus* Assemblage Zone (Table 2), proliferates in the *Tropidostoma* Assemblage Zone and persists as a rare member in the *Cistecephalus* Assemblage Zone (Rubidge, 1995).

The dicynodont assemblage of the Kundaram Formation is dominated mainly by *Endothiodon*. Thus, in comparison to the South African Late Permian faunas, the Indian faunal association is at present not sufficiently known for precise correlation. The captorhinid is yet to be described, but the presence of *Endothiodon* and *Cistecephalus* indicates a broad correlation with the *Tropidostoma* and/or *Cistecephalus* Assemblage Zones of the Beaufort Group of South Africa.

The fossils collected from the Madumabisa Mudstones of the Luangwa Valley, Zambia (Kemp, 1976) suggest a latest Permian age. The lower bed is characterised by *Endothiodon*, *Dicynodon*, *Emydops* and *Pristerodon,* while the middle and the upper beds contain *Cistecephalus* and *Dicynodon*. King and Jenkins (1997) suggested that the age of this succession is very near the Permian–Triassic boundary. The ranges of *Endothiodon, Cistecephalus* and *Dicynodon* overlap only in the *Cistecephalus* Assemblage Zone of South Africa (Rubidge, 1995). As a result, the lower bed of the Madumabisa Mudstones can be correlated with the *Cistecephalus* Assemblage Zone and the middle and upper beds with the *Dicynodon* Assemblage Zone and *Dicynodon* and/or *Lystrosaurus* Assemblage Zones, respectively. Accordingly, the lower bed of the Madumabisa Mudstones is probably slightly younger than the Kundaram Formation (Table 3).

Table 4. A correlation of the Permian horizons of the Gondwana basins of India (after Pascoe, 1959; Robinson, 1970; Rao, 1982; Ray, 1997)

Age	Damodar Valley		Son-Mahanadi Valley	Satpura	Pranhita Godavari Valley
TRIASSIC		Panchet	Parsora	Pachmari	Kamthi (Middle)
PERMIAN	DAMUDA				Kamthi (Lower)
		Raniganj	Pali and Hingir	Bijori	Kundaram
		Barren Measures		Motur	
		Barakar	Barakar	Barakar	Barakar
		Karharbari			
	←-------------Talchir-------------→				

The Kawinga Formation of Tanzania is considered to be homotaxial with the Late Permian part of the Beaufort Group of South Africa (Haughton, 1932). Dicynodonts identified from this formation are *Dicynodon*, *Rhachiocephalus*, *Endothiodon*, *Pachytegos*, *Cryptocynodon*, *Kawingasaurus*, *Kingoria* and *Pelanomodon* (King, 1992). From the underlying Ruhuhu Formation, a fauna including *Endothiodon* (Cruickshank, 1986) is correlated with the *Tropidostoma* and/or *Cistecephalus* Assemblage Zones and the Kundaram Formation of India.

In addition to Africa and India, *Endothiodon* is known also from the Morro Pelado Member of Rio do Rasto Formation in the Paraná Basin, Brazil (Barberena *et al.*, 1985). It forms a part of the Serra do Cadeado local fauna (Barberena and Araujo-Barberena, 1991), which also includes long and short snouted rhinesuchid temnospondyls. This horizon is equivalent to the *Cistecephalus* Assemblage Zone of South Africa and can be correlated partly with the Kundaram Formation. Thus, the Kundaram Formation is correlated with other Late Permian deposits (Table 3) that suggest a Tatarian age.

The Gondwana rocks of Permian age in India are subdivided into the Talchir Formation and the overlying coal-bearing Damuda Group (Table 4). The sediments of the latter are best preserved in the Damodar Valley Basin (Fig. 1), where they are subdivided further into the Karharbari, Barakar, Barren Measures and Raniganj Formations (Table 4). The Talchir and overlying Barakar Formations are distinctly recognisable in most of the Gondwana basins of India. The upper boundary of the Barakar Formation, though not well-defined, is based usually on the presence of coal seams. The formations overlying the Barakar Formation in the different Gondwana basins have been named differently, depending on lithological characteristics and fossil contents.

The Damuda Group is characterised by the *Glossopteris* flora, including such genera as *Phyllotheca*, *Sphenophyllum*, *Glossopteris* and *Gangamopteris*. The *Glossopteris* flora, in turn, is again divided into two floral assemblage zones, an earlier *Gangamopteris* and a later *Glossopteris* zone (Shah *et al.*, 1971). *Gangamopteris*, considered as the most primitive of the glossopterids, is found mostly in the Early Permian rocks of India. The basal unit of the Damuda Group, the Karharbari Formation, is dominated by *Gangamopteris* and *Noeggerathiopsis* (Chandra, 1992), while the overlying Barakar Formation is characterised by the genus *Glossopteris*. Other genera include *Phyllotheca*, *Schizoneura* and *Trizygia* (Chandra, 1992). The *Glossopteris* flora is best developed in the overlying Late Permian Raniganj Formation and is represented by several species of *Glossopteris*, *Schizoneura* and *Vertebraria*. Thus the wide and overlapping range zones of the different species of *Glossopteris* broadly suggest a Late Permian age to the upper part of the Damuda Group. *Gondwanasaurus bijoriensis* from the Bijori Formation of Satpura Basin also suggests a Late Permian age (Werneburg and Schneider, 1996). The reptilian fauna of the Kundaram Formation, which is probably coeval with the Raniganj Formation of the Damodar Valley, the Bijori Formation of the Satpura Basin and the Pali and Hingir Beds of the Son-Mahanadi Valley (Table

Table 5. Distribution of the four Late Permian dicynodont genera (after Kutty, 1972; Anderson and Cruickshank, 1978; Barberena *et al.*, 1985; Mazin and King, 1991; King, 1992).

South Africa	India	Malagasy	Tanzania	Zambia	Mozambique	Brazil
Endothiodon	+		+	+	+	+
Cistecephalus	+					
Pristerodon	+		+			
Oudenodon	+	+		+		

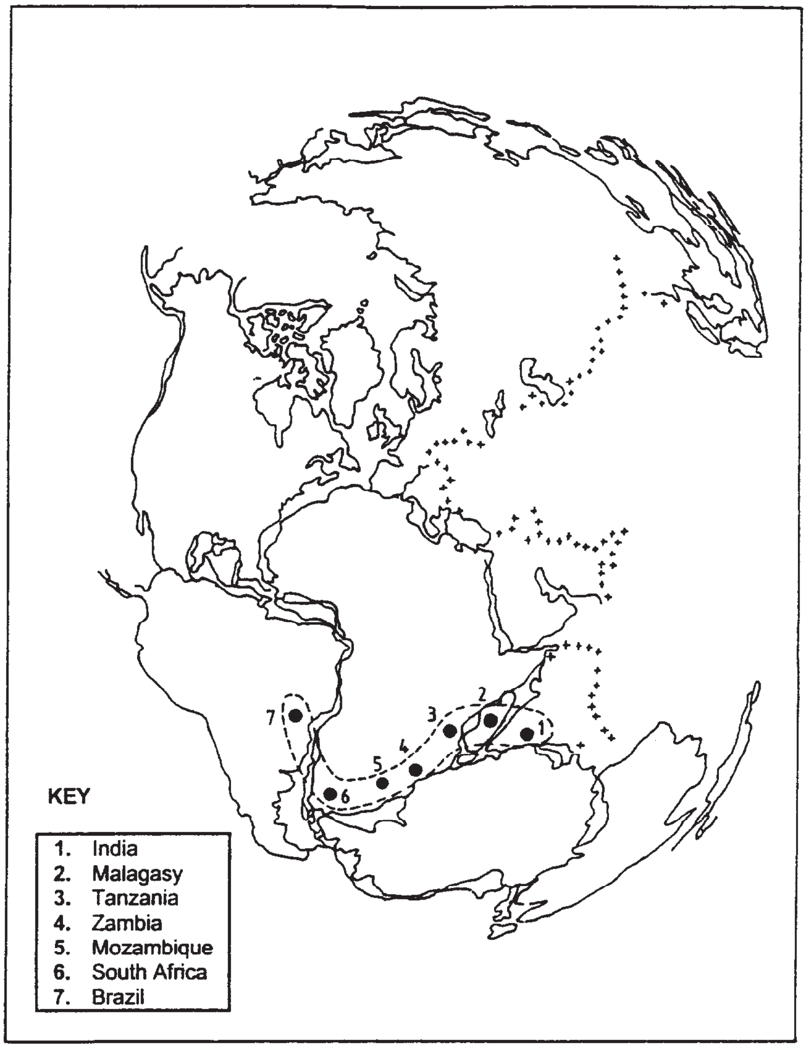

***Figure 3.** Distribution of the four Late Permian dicynodonts* Endothiodon, Cistecephalus, Oudenodon *and* Pristerodon. *(Pangæa reconstruction after Smith* et al., *1981). The cross-hatched line indicates the Circum-Tethyan shoreline.*

4), helps in fixing the age of the upper part of the Damuda Group more precisely at Tatarian.

The distribution of Late Permian dicynodonts, especially in the southern hemisphere (Fig. 2) suggests that there was no apparent physical barrier between these regions. An early Late Permian Tapinocephalid Empire, followed by an Dicynodontid Empire, was suggested by Anderson and Cruickshank (1978). The distribution of the dicynodont genera, *Endothiodon, Oudenodon, Pristerodon* and *Cistecephalus* (Table 5), when plotted on a palæogeographic map of Pangæa (Fig. 3), shows that the areas lie in a more or less broad and regular zone describing an arc that stretches from Brazil in the west to India in the east. The zone suggests both the close proximity of the continents during that time and a lack of endemism or provinciality among these genera.

SUMMARY

The faunal content of the Kundaram Formation of Pranhita-Godavari Valley, India is dominated by dicynodonts, including *Endothiodon, Cistecephalus, Oudenodon, Pristerodon* and *Emydops*-like forms. The only non-dicynodont member is a captorhinid reptile. This fossil assemblage correlates the Kundaram Formation with the *Tropidostoma* and/or *Cistecephalus* Assemblage Zones of the Beaufort Group of South Africa, the basal beds of the Madumabisa Mudstones of Zambia, the Ruhuhu and lower part of the Kawinga Formations of Tanzania and the Morro Pelado Member of the Rio do Rasto Formation of Brazil. The Kundaram fauna helps in ascertaining the upper age of the Damuda Group of India to be Tatarian. The wide distribution of the Late Permian dicynodonts suggests that free migration was possible, resulting in the radiation of the highly diverse South African Karoo fauna into now widely separated geographic regions.

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