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NEW *BALOCHISAURUS* (BALOCHISAURIDAE, TITANOSAURIA, SAUROPODA) AND *VITAKRIDRINDA* (THEROPODA) REMAINS FROM PAKISTAN

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Abstract

From first ever to until now about 30 localities of dinosaurs and crocodiles are discovered from Mesozoic of Pakistan. Among these one locality (Baroch Nala of Malakhel area) from middle Jurassic of Kohat and Potwar Basin, 25 localites (PDL-1 to PDL-25 from Vitakri region include Vitakri, Gambrak and Mari Bohri areas, Rakhni region include Mat Khetran and Karcha-Jhabbar areas, Baeker region include Bhal area, and Fort Munro region include Top Girdu and Mian Ghundi Khar areas) from the latest Cretaceous of Sulaiman Basin and 4 localities like Sun Chaku and Charow from Late Jurassic, and Karkh and Khuzdar from Late Cretaceous of Kirthar basin are known so far. *Balochisaurus* (Balochisauridae, Titanosauria, Sauropoda) remains have been found from the latest Cretaceous Vitakri Formation (previously upper member of Pab Formation) in Mari Bohri, Kinwa Kali Kakor, Basti Nala (Zubra) Gambrak, Bor Kali Kakor, Grut Gambrak and some other localities of Sulaiman basin, Pakistan. These fossils provide new insights in to skull and postcranial morphology. Multipurpose tail special with trispinous distalmost caudal centrum of *Balochisaurus* (along with some other genera) from Pakistan provides a new look of titanosaurs. The skull discoveries of *Balochisaurus (Marisaurus* and *Pakisaurus)* from Pakistan add the skull diversity of titanosaurs. Due to dearth of cranial data and lack of common associated elements in titanosaurs has left even the most basic skeletal morphology of the clade controversial and has precluded detailed study of its higher and lower level phylogeny, but now Pakistan has this advantage which produced associated cranial, axial and appendicular elements of ***Balochisaurus*** *(Marisaurus* and *Pakisaurus*).

Large bodied *Vitakridrinda* (Theropoda) remains have been found from Alam, Bor, Sangiali, Shalghara, Kinwa, Top Kinwa, Mari Bohri etc. localities of Sulaiman basin and Karkh area of Kirthar Basin. New remains from many sites and an articulated elements of pes, along with the confrontation scenario between two *Vitakridrinda* deduced from its holotypic rostrum are also being described here.

Keywords: *Balochisaurus*, Balochisauridae, Titanosauria, Vitakri Formation, *Vitakridrinda*, Theropoda, Late Cretaceous, Pakistan, Malkani.

1. Introduction

Wilson (2006) mentioned "the first dinosaur fossils from India were discovered in 1828". Powell (2003) mentioned "Falconer submitted the first report on Indian dinosaur fossils in 1862 but published as posthumous memoir in 1868". But from Pakistan, since 2000 (first discovery) to date about 3000 fossils of cranial, vertebral and appendicular elements of latest Cretaceous archosaurs were collected during recent studies which include *Khetranisaurus*, *Sulaimanisaurus* and *Pakisaurus* of Pakisauridae, and *Marisaurus* and *Balochisaurus* of Balochisauridae (Titanosauria, Sauropoda), and *Vitakridrinda* abelisaurid theropod (Malkani and Anwar 2000; Malkani *et al*., 2001; Malkani 2003a,b; 2004a; 2006a,b,c,d,e; 2007a,b,c,e,f; 2008a,b,c,d,e,f; Wilson *et al*., 2005) and *Pabwehshi* baurusuchid mesoeucrocodile (Wilson *et al*., 2001; Malkani 2004b, 2007d). The *Brohisaurus kirthari* (Titanosauria) from the J/K boundary of lower Indus (Kirthar Range) basin has also been established (Malkani 2003c). The trackways of wide gauge titanosaurian sauropods

(*Malakhelisaurus mianwali*) confronted by a running narrow gauge abelisaurian theropod (*Samanadrinda surghari*) found from the Middle Jurassic limestone of upper Indus (Kohat and Pothwar) basin represents gregarious defending behavior of early titanosaurian sauropods, and predatory hawk like behaviour (not vulture) of early theropods (Malkani 2007a; 2008f). *Balochisaurus* along with four other genera and their two family of Titanosauria from Pakistan were first time reported by Malkani (2004a), and this classification along with figures is formally published in (Malkani 2006b). Here associated and fragmentary remains of *Balochisaurus and Vitakridrinda*, and a confrontation scenario between two *Vitakridrinda* is evidenced on its holotypic rostrum, are being described.

2. Matetrials and Methods

The materials belong to the field data and collected bones of *Balochisaurus* and *Vitakridrinda* from 2000 to date from Pakistan **(Fig. 1-9)**. The methods applied for this research is paleontological scientific which include description, drawing, discussions and conclusions.

3. Results and Discussions

General Geology of the Sulaiman basin

The southern Sulaiman fold and thrust belt has produced well developed and well preserved fossils of archosaurs. The area is folded and faulted with general relief varies from 200m to 2000m. Topography represents mostly rugged mountain ranges with some semi plain valleys. Stratigraphic formations are; Jurassic Sulaiman group consists Spingwar, Loralai and Chiltan formations; Early Cretaceous Parh Group represents Sembar, Goru and Parh formations; Late Cretaceous Fort Munro group represents Mughal Kot, Fort Munro, Pab and Vitakri formations; Paleocene Sangiali group represents Sangiali, Rakhi Gaj and Dungan formations; Early Eocene Ghazij group resrents Shaheed Ghat, Toi, Kingri (red muds with some horizons of grey sandstone well exposed in the Kingri, Bahlol, Chamalang areas, etc; best reference section is just 1km northwest of Kingri Village 39 F/15), Drug and Baska formations; Late Eocene Kahan group represents Habib Rahi, Domanda, Pirkoh and Drazinda formations; and Early Oligocene to Late Pliocene Vahowa (=Vahoa =Vihowa=Vihova=Vahova) group represents Chitarwata, Vahowa, Litra and Chaudhwan formations; alongwith Pleistocene Dada Formation and Subrecent and Recent surficial deposits. The Sangiali Formation consists of glauconitic shale and sandstone and yellowish brown bivalve bearing limestone. The type locality of Sangiali formation and group (grid reference; 29^0 41' 53'' North, 69^0 23' 54'' East) is well exposed just 1km south southeast of village Sangiali. The lower contact of Sangiali formation with Vitakri formation and upper contact with Rakhi Gaj Formation are well observed. Coal, gypsum, celestite, iron, silica sand, cement raw material and aggregate and bed rock resources represents major economic potential. Present study represents the new discoveries like Coal from latest Cretaceous Vitakri Formation of Kingi area, coal from early Eocene Toi Formation of Toi Nala and Mirriwah/Baghao, and coal from late Eocene Domanda Formation of Rakhni (Lakha Kach), Rakhi Gaj and foot mountain areas of Sulaiman Range, coal and iron from Oligocene Chitarwata Formation of eastern foot mountain areas of Sulaiman Range; celestite from early Late Eocene Drug Formation of Barkhan, Kohlu, Musa Khel and Dera Bugti districts; gypsum from many localities of Sulaiman Basin; Iron and potash (glauconite, siderite and hematite) from Paleocene Rakhi Gaj Formation of Girdu, Khar, Fort Munro, Rakhi Gaj, Choti Nala and their vicinity areas (Malkani 2004c; Malkani in process).

Dinosaur localities in Pakistan

Baroch Nala of Malakhel area (Mianwali District) represents three main sites of the middle Jurassic trackways on Samanasuk Limestone. The southern site have only exposed one sauropod hindlimb footprint, the middle site represents two trackways of smaller nonavian (possibly avian) theropods, and northern site represents represent interaction among walking wide gauge titanosaurian sauropods and a running narrow gauge (possibly abelisaurian or its ancestor) theropod (Malkani, 2007a; 2008f) and a few fragmentary fossils (poorly preserved and poorly recognized) of sauropods from Late Jurassic Sun Chaku and Charo areas and Late Cretaceous Karkh and Khuzdar areas (Khuzdar District; Malkani, 2003c)) **(Fig. 1 abc).** Well developed and well preserved latest Cretaceous terrestrial fauna from Sulaiman basin include 25 Pakistani.

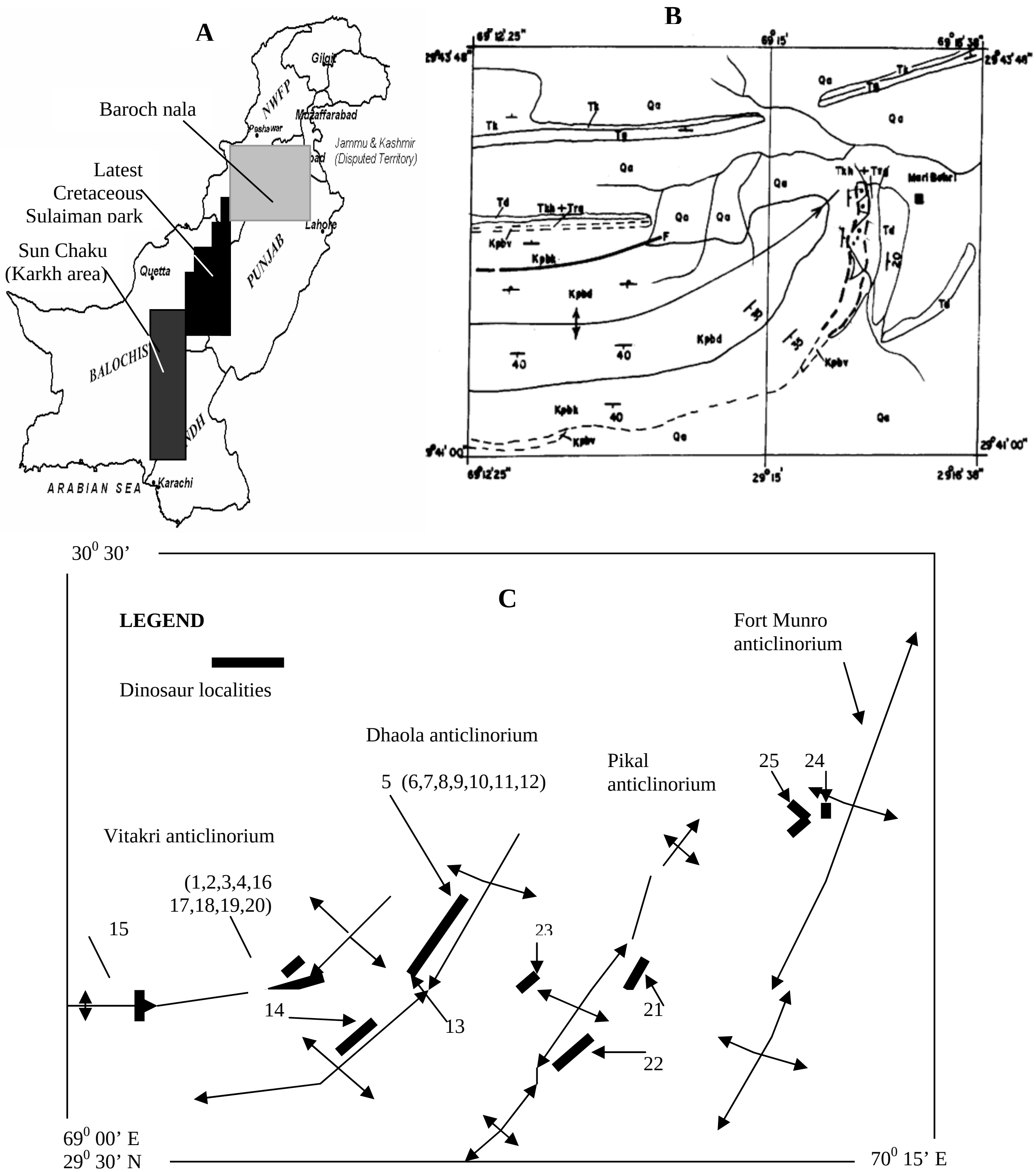

Fig. 1. A, light grey (upper) rectangle represents Kohat and Pothwar Basin, black (middle) rectangles represent the study area of Sulaiman Basin, medium grey (lower) rectangle represents Kirthar Basin of Pakistan.

B, represents the map of Mari Bohri locality and fossil sites (dots), for symbols see Fig.2.

C, represents the four major anticlinoria including the latest Cretaceous terrestrial fauna and their localities in Sulaiman Basin

dinosaur localities (PDL-1 to PDL-25;) have been discovered in the following main four regions.

Vitakri Region, Barkhan District: This region has Vitakri, Gambrak, Sadiqani-Chaper and Mari Bohri areas. **Vitakri area** consists of nine localities **(Fig. 2a,b).** The names of localities are mostly based on the stream or landowner or village names. These localities are found in the just east of Vitakri town and situated on the slope of Vitakri hills. The exposures of Vitakri Formation are found around the stream cuts. Structurally these localities are found in a dome like anticline which has many faults trending NE. This dome has radial drainage pattern. This dome represents mostly the exposures of Vitakri Formation (Dinosaur beds) except the eastern and northeastern part which is covered by Paleocene Sangiali Formation. The dips of strata of northwestern limb of Vitakri anticline is low as 5^0. This limb consists of PDL 1-4, 16, 18-20. The dip of southeastern limb is high up to 60^0 and it consists of PDL-17 (Fig. 2a,b). Vitakri anticline (Fig. 2,1c) together with the Mari Bohri anticline (Fig. 1b,c) forms Vitakri anticlinorium **Sangiali Kali Kakor locality (PDL-1)** is named from the stream confronting the Sangiali Village. One caudal vertebra (Malkani, 2006b;) of *Vitakridrinda* theropod is found from this locality. The present author also collected the first fossil of dinosaur from this locality (Malkani and Anwar, 2000). This locality has three main sites from where the dinosaur fossils are found. One eastern site produced fragmentary but associated about 100 fossils with a simple armour plate of one individual of *Sulaimanisaurus*? The western site have associated bones may belong to *Pakisaurus*, diagnosed on the basis of caudal tall vertebrae hosted in the field site. The southern site represents some fossils of stocky limbed Balochisauridae which are found as disseminated in the upstream area. **Bor Kali Kakor locality (PDL-2)** is named from the stream confronting the Vitakri Village. This locality has three main sites (Fig. 2) from where the dinosaur fossils are found. All these three sites are found on the south of stream. The western site has produced the remains of *Pakisaurus*, central site the remains of *Marisaurus* and *Vitakridrinda*, and eastern site (not marked on map) has produced only a few appendicular elements. Some disseminated fossils like one caudal vertebra of *Sulaimanisaurus* and one caudal vertebra of *Khetranisaurus* (Malkani, in process), and one caudal vertebra of *Balochisaurus* were found (Malkani, 2006b).

Shalghara Kali Kakor locality (PDL-3) is named after the heap of sandstone clasts called Shalghara by local peoples (Fig. 2a,b). This locality has also yielded three articulated vertebrae (under specimen preparation with David Krauass, Bostan College. USA), and articulated anterior dentary/mandibular rami of *Pabwehshi* (GSP-MSM-4-3; changed number GSP-UM 2001; Wilson, *et al*., 2001;), some remains of *Pakisaurus*, and *Vitakridrinda.* **Kinwa Kali Kakor locality (PDL-4)** is named from the hot gas springs called Kinwa by local peoples (Fig. 2). This locality is enriched in fossils and has eight or more main sites from where the dinosaur fossils are found. All these sites are found on the west and northwest of mainstream. Some fossils were also found disseminated. The southern most three sites are located near the west and southwest of Kinwa water spring. These sites have yielded the remains of possibly *Sulaimanisaurus, Pakisaurus, Marisaurus and Balochisaurus*. The site on the south of peak just near the west of Kinwa (gas water spring) has produced a rostrum of *Balochisaurus* on partial excavation. The central three or more sites are located on the banks of small branch stream flowing fron northwest, dropping its load near the water-gas spings in to main stream of Kinwa. These westernmost sites possibly have produced the remains of *Pakisaurus* and *Sulaimanisaurus*. It has also yielded articulated anterior dentary rami of *Pabwehshi*. Mid Kinwa representing *Balochisaurus* skull and caudal vertebrae, found west of main Kinwa stream, near the north of junction of previously described branch stream with main Kinwa stream. It has also produced one holotypic and one referred specimen of *Khetranisaurus.* The northern site is located on the west of main Kinwa stram at the junction of way to Bor stream. Here associated cranial and postcranial remains of young *Balochisaurus* are found. North of this site, the top Kinwa locality started. Three main sites **(Fig. 2)**.

Top Kinwa Kali Kakor locality (PDL-16) is named from the upper portion of Kinwa stream.

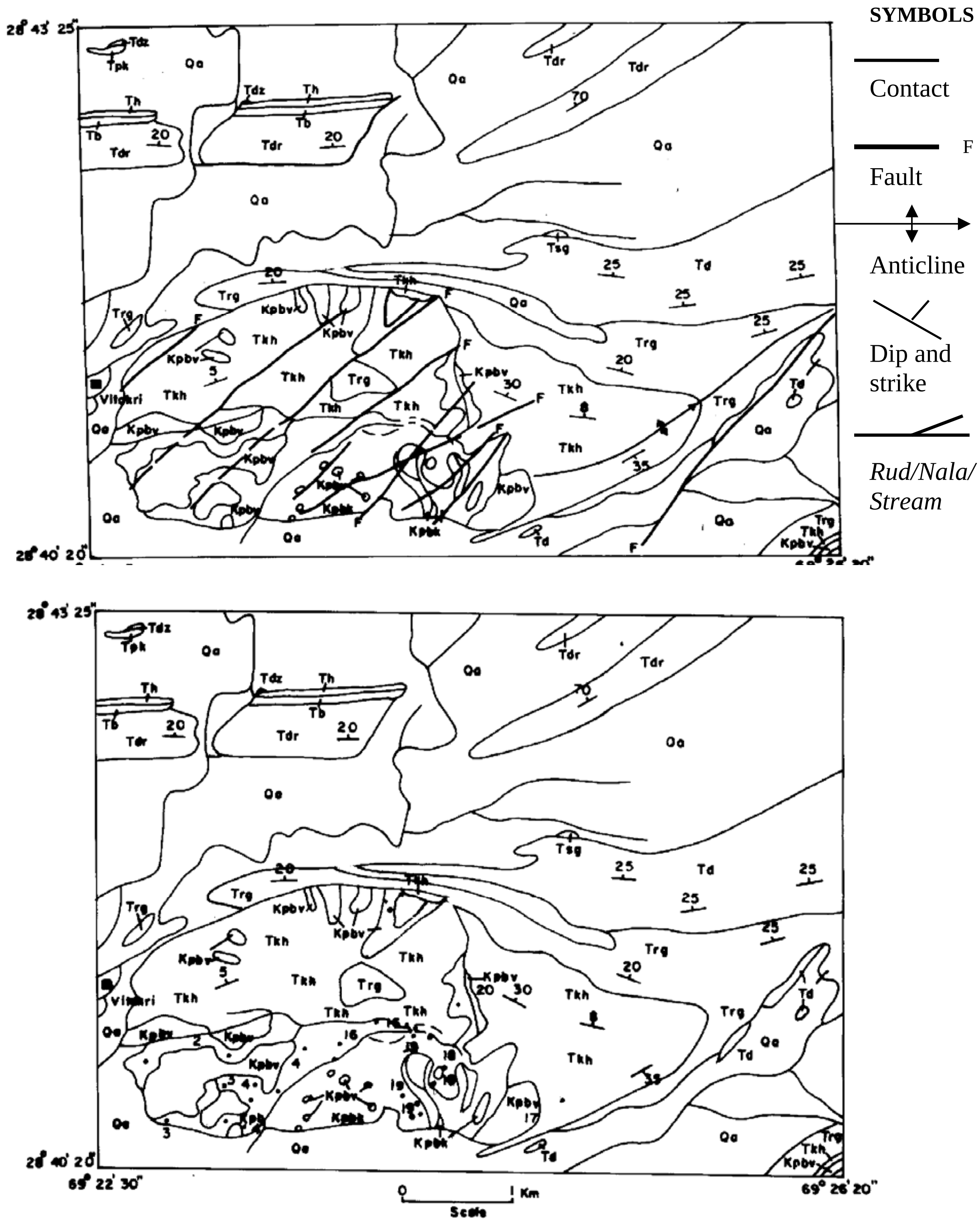

Fig. 2. Upper, Geological map of Vitakri area. Lower, Dinosaur localities and fossil sites (dots) map of Vitakri area. Abbreviation; Qa, Alluvium; Tdz, Drazinda F. Tpk, Pirkoh F.Tdm, Domanda F. Thr, Habib Rahi F. Tb, Baska F. Tdr, Drug F.Tsg, Shaheed Ghat FTd, Dungan F.Trg, Rakhi Gaj F Tkh, Khadro F. Kpbv, Vitakri F. Kpbk, Kali mem. Kpbd, Dhaola mem.

This locality has five main sites from where the dinosaur fossils are found. Two sites are found close to each other in lower reaches, while the third site is found in the northern maximum reaches and last two sites are found also close each other in the top reaches on the east. The last site has produced a rostrum (original number GSP-MSM-3-16; changed number GSP-UM-2000) of *Pabwehshi pakistanensis* mesoeucrocodyle (Wilson, *et al*., 2001), a braincase (original number GSP/MSM-2-16; changed number GSP-UM-2007; Wilson *et al*. 2005), and associated remains of *Marisaurus* (Malkani, 2006b; 2008f). The northern central site has yielded some associated remains of *Pakisaurus.* Some fragmentary pieces of limb elements were also found from the southwestern site. Further one fragmentary caudal vertebra of *Balochisaurus,* and two asociated caudal vertebrae of *Balochisaurus* are found as disseminated.

Alam Kali Kakor western locality (PDL-19) is named from the nearby lands owner Alam Khetran. This locality has three main sites from where the dinosaur fossils are found. All these three sites are found on the western extremity of Alam stream. The southern site (PDL-19s) has few appendicular elements. The central site (PDL 19 or 19c) has produced the associated fossils of *Marisaurus* and *Vitakridrinda*. The northern site (PDL. 19n) has produced associated remains of *Pakisaurus*. This site is very close to Top Kinwa *Marisaurus* site. Alam Kali Kakor eastern Locality (PDL-18). Include some vertebral and appendicular elements of *Balochisaurus* on north eastern portion, while some remains are also observed in central portion just on the escarpment of central ridge of Some fossils are collected from Dada Pahi Kali Kakor Locality (PDL-17) and Rosmani Kali Kakor Locality (PDL-20).

Mari Bohri area consists of Mari Bohri lcality (PDL-15), which is named from the nearby village of Mari Bohri (Fig. 1b). This locality is found about 15 km in the west of Vitakri town. This fossil locality is situated on the eastern plunge of Mari Bohri anticline. The northern limb of this anticline extends up to Mawand area via Chang Mari and Fazil Chil, while southern limb also extends upto Mawand area via Makhmar. The dips of Mari Bohri dinosaur locality are variable upto 40^0 toward east. This locality is found just west of Mari Bohri village. The northern limb of this anticline is also faulted in the Chang Mari area to Fazil Chil. This locality has produced associated vertebral and limb remains of *Marisaurus* and *Balochisaurus*. This locality has five main sites from where the dinosaur fossils are found. The northern most sites have produced a proximal and distal femur, possibly pubis and or ischium, and a biconvex first caudal vertebra of *Marisaurus.* The nearby other site may be 70 m separated by a fault, yielded a series of associated caudal vertebrae of *Marisaurus;* and other sites may be 400 m towards SSW yielded a biconvex first caudal vertebra along with a series of associated presacral and caudal vertebrae and limb remains of *Balochisaurus.* Further 100m towards SSW, a femur was found. Further this area has yielded some remains of *Pakisaurus*, *Khetranisaurus* and *Sulaimanisaurus* and *Vitakridrinda*. In the Chang Mari area (northwest of this locality) the upthrusting of Vitakri formation form a gravity flow or slope like volcano. Previously by some worker marked it as Kohlu volcano.

Gambrak area consists of nine localities These localities are found in the south east of Nahar Kot town. These localities area found as a long belt/strip on the northwestern limb of Dhaola anticlinorium (Fig.1c). Starting from northeastern extremity of this belt as PDL-5 and ending in to southwestern extremity as PDL-13. Between these localities, the other localities on approximately equal distance are found. The dips of strata of northwestern limb of this anticline are high up to 75^0 and vertical. Dagar Gambrak Locality (PDL-5) and Goes Wanga Pass Gambrak (PDL-6) has produced some remains of Balochisauridae and Pakisauridae and a woodlog of gymnosperm from Pab Formation representing evergreen the Late Cretaceous Greenhouse Park of Sulaiman Basin, Pakistan. Basti Nala (Zubra) Gumbrak, (PDL-7) have produced some remains of *Pakisaurus* from the peak site, and caudal vertebra and a thick oval osteoderm (MSM-84-7) of *Balochisaurus* from the southern limb of peak. Darwaza Gambrak Locality (PDL-8) has produced scapula of *Pakisaurus*, and one caudal vertebra and one presacral vertebra of *Marisaurus* and some presacral vertebrae are also existed in the field site. Grut Gambrak Locality (PDL-9) has produced remains of *Balochisaurus*, *Pakisaurus* and *Khetranisaurus.* Rahi Wali Gambrak (PDL-10) has produced a few remains of *Balochisaurus.* Dolwahi northeast (PDL 11) has produced distal humerus. Dolwahi Eastnortheast (PDL-12) and Dolwahi East (PDL-13) have produced some remains of Pakisauridae and Balochisauridae. **Sadiqani-Chapar area** consists of a folded belt of dinosaur beds. This belt is found in the south and west of Vitakri town. It consists of Sadiqani Chapar Locality (PDL-14). This locality is found as a long belt/strip on the northwestern limb of Andari anticline (a part of Dhaola anticlinorium). (Fig. 1c). Only one fossil is collected from this locality but horizon and bones exist there. The dips of strata of northwestern limb of this anticline are high up to 75^0 and vertical. This area extends in to Makhmar area also.

Rakhni region, Barkhan District: Mat Khetran area is located on the eastern flank of Pikal anticline of Pikal anticlinorium. It consists of one locality such as PDL-21. The name of this dinosaur locality is Mat Khetran. This locality is found 20 km in the south of Rakhni town. This locality is found on the eastern side of northern plunge of Pikal anticline. The Pikal anticlinorium consists of Phulani, Pikal and Siah Koh anticlines. This locality extends in to southwest in to Bhal locality of Beakaer area of Dera Bugti District. The Mat Khetran and Bhal locality form a discontinous belt located on the eastern flank of Pikal anticline. Only a few fossils of this locality are collected, only horizon was explored. This horizon can be explored in to Siah Koh anticline. **Kachar area** has Kachar locality (PDL-24; Fig. 1c) exposed in major Rakhni synclinorium. Rakhni synclinorium consist of Kachar syncline which extends further west in to Jhabar-Nisau syncline and further east in to Rakhni syncline and ultimately into Manjhail-Kharar Buzdar syncline. The western part of Kachar-Jabbar area located in the southeastern flank of Dhaola anticlinorium and eastern part of this area is located in the northwestern limb of Pikal anticlinorium.

Jhabar-Nisau Region of Kohlu District: The Jhabar area extends toward west to the Nisau area of Kahan Tehsil (Kohlu District). This area has exposures of Vitakri Formation on the eastern limb of Dhaola-Andari anticlinorium and on the western limb of Pikal-Siah Koh anticlinorium. These areas are significant for further dinosaur research and exploration.

Baekar region of Dera Bugti District: Bhal (PDL-22) is located on the eastern flank of Pikal anticline. Further south there is a Siah Koh anticline (Fig. 1c). Up to now only a few fragmentary pieces of bones of titanosaurian dinosaur are collected, however horizon was marked, observed and documented.

Fort Munro –Chitri region, Dera Ghazi Khan and Rajan Pur districts: It is located on the Fort Munro anticlinorium. Fort Munro area extends up to Chitri area of Rajan Pur District in the south, and up to Shadani area in to north. Two localities are marked like PDL-23, named as Top Girdu which is located on the top elevation of Girdu peak (near the metalled road turn east of mosque) and PDL-25 named as Khar Fort Munro (Mian Ghundi) is which is found just near the west and north west of Khar bus stop. Some bones were found and left in places. Both these localities are found on the top of main peaks of Fort Munro Range. The limb of this anticlinorium is significant for further dinosaur and related paleontological studies.

New *Balochisaurus* (Balochisauridae, Titanosauria) remains found from Pakistan

Holotype and locality; Its Holotypic materials are seven fragmentary but seem associated caudal vertebrae (MSM-43-15, MSM-44-15, MSM-44a-15, MSM-45-15, MSM-46-15, MSM-47-15, and MSM-48-15), collected from the Mari Bohri locality (Malkani, 2006b, fig. 5-8).

Referred specimens and localities: First time, the caudal vertebrae of *Balochisaurus* were described by Malkani (2004a), second time the specimens' MSM-49-16 fragmentary caudal vertebra, MSM-50-4 and MSM-51-4 associated caudal vertebrae and MSM-52-9 fragmentary caudal vertebra (Malkani, 2006b, fig. 9-12), and MSM-142-4 a partial rostrum (Malkani 2006b, fig. 21b) were described and figured by (Malkani 2006b), third time the presacral vertebrae (MSM-126-15, MSM-127-15, MSM-128-15, MSM-129-

15, MSM-130-15) were described and figured by Malkani, (2006c; fig. 2-5) which are being referred to *Balochisaurus* based on fossils association. The holotypic and referred materials of above mentioned localities might be associated with some or all materials of *Balochisaurus* from the relevant following localities. Here the following materials are being described and referred. **Bor** locality yielded caudal vertebra MSM-360-2. The southwesten site of **Basti Nala (Zubra)** locality yielded possibly associated mid caudal vertebrae MSM-523-7, MSM-524-7 mid scapula MSM-746-7 and thick armor plate (MSM-84-7; Malkani 2008f). **Grut Gambrak** yielded possibly associated right corocoid MSM-752-9 and distal ulna MSM-252-9 (Fig. 7b), and distal stocky tibia (MSM-75-9; Malkani 2006b, fig. 19a). **Kinwa** locality produced caudal vertebrae MSM-512-4, MSM-514-4, MSM-811-4 MSM-515-4 MSM-808-4 Kinwa southwest site produced rostrum/ partial skull (MSM-142-4, **Fig. 3,4,5,6)**. Kinwa mid (north) site yielded associated caudal vertebrae MSM-1021-4m (north), MSM-1018-4m (north), and MSM-1019-4m (north), while Kinwa mid (south) site yielded partial skull MSM-1016-4m (Fig. 7a) and caudal vertebra MSM-1017-4m-south and Kinwa north site yielded associated specimens like presacral vertebrae MSM-383-4n, MSM-382-4n and MSM-381-4n , MSM-347-4n, MSM-348-4n, MSM-212-4n a pair of left and right distal femora MSM-190-4n and MSM-192-4n, proximal radius MSM-344-4n, five teeth in jaw ramus MSM-138-4n, skull and teeth fragments in matrix MSM-315-4n and MSM-314-4n, neural spine with post zygapophyses and prespinal laminae of dorsal vertebra MSM-323-15 and chevron MSM-313-4n (Fig. 7), left femur MSM-190-4n, a pair of distal tibia stocky MSM-346-4n, MSM-345-4n, femur sections MSM-378-4n, MSM-270-4n, distal femur MSM-192-4n, and humerus parts MSM-380-4n, MSM-377-4n, MSM-379-4n, MSM-438-4n (Fig. 7). **Mari Bohri** yielded associated prescaral vertebrae MSM-824-15, MSM-823-15, MSM-8-15, MSM-818-15, (Fig. 5,7); caudal vertebrae, MSM- 260- 15, MSM-505-15, MSM-834-15 **(Fig. 5),** proximal left femora MSM-167-15, MSM-168-15, MSM-749-15, Proximal fibula MSM-672-15, distal tibia MSM-227-15, proximal humerus MSM-717-15, distal humerus MSM-258-15, distal femora MSM-170-15, MSM-173-15, proximal humerus MSM-245-15, proximal left tibia MSM- 246-15, distal humerus MSM-174-15, cervical rib MSM-881-15 (and MSM-322-15;), possibly distal rib MSM-1056-15, anterior sternal MSM-675-15, proximal metacarpal MSM-297-15, distal metacarpal MSM-750-15 **Fig. 3-6)**; sternal MSM-675-15, acetabulum MSM-166-15, proximal rib of dorsal vertebra MSM-322-15, cervical neural spine MSM-324-15, and dorsal neural spine MSM-323-15 and proximal ulna (MSM-78-15, Malkani 2006b, fig. 20a,b). **Rahi Wali Gambrak** (PDL 10) has produced a proximal humerus MSM-237-10

Some materials of Malkani (2006b) like proximal ulna (MSM-78-15; Malkani 2006b, fig. 20a,b), and stocky distal tibia (MSM-75-9; Malkani 2006b, fig. 19a) are being assigned to *Balochisaurus*, stocky proximal tibia (MSM-73-16; Malkani 2006b, fig. 18a,b), and a pair (left and right) of proximal fibula (MSM-76-16, MSM-77-16; Malkani 2006b, fig. 19a) are being assigned to *Marisaurus* (Malkani, 2008f), slender distal femur (MSM-71-15; Malkani 2006b, fig. 17a,b) and slender proximal tibia (MSM-72-2, Malkani 2006b, fig. 18a,b) are being assigned to *Pakisaurus*. MSM-504-15 is being attributed to *Sulaimanisaurus*, and MSM-520-2, MSM-525-9 and MSM-833-15 are being attributed to *Khetranisaurus* (Table 1). It is necessary to mention that a distal ulna MSM-74-16 (Malkani 2006b, fig. 19a) is mis spelled as distal tibia in Malkani (2006b). All holotypic and referred materials from this locality are housed at the Museum of the Geological Survey of Pakistan, Quetta. In Fig.5a fourth column (Malkani 2008f) mistyped as humerus parts, in actual the MSM-181-2 is a proximal tibia and MSM-362-2 is a distal tibia, both are stocky and belongs to *Marisaurus*.

Horizons and Age: The *Balochisaurus* remains are collected from the latest Cretaceous fluvial Vitakri Formation of Sulaiman Basin, Pakistan. Most of these materials were found as fragmentary clusters or heap forming or close occurrences, while some materials as isolated and dispersed. The heap or cluster of bones represents associated materials of different fauna, while fragmentary isolated bone represents transportation before deposition. The taphonomy and depositional environments of Vitakri Formation (previously Vitakri Member of upper.

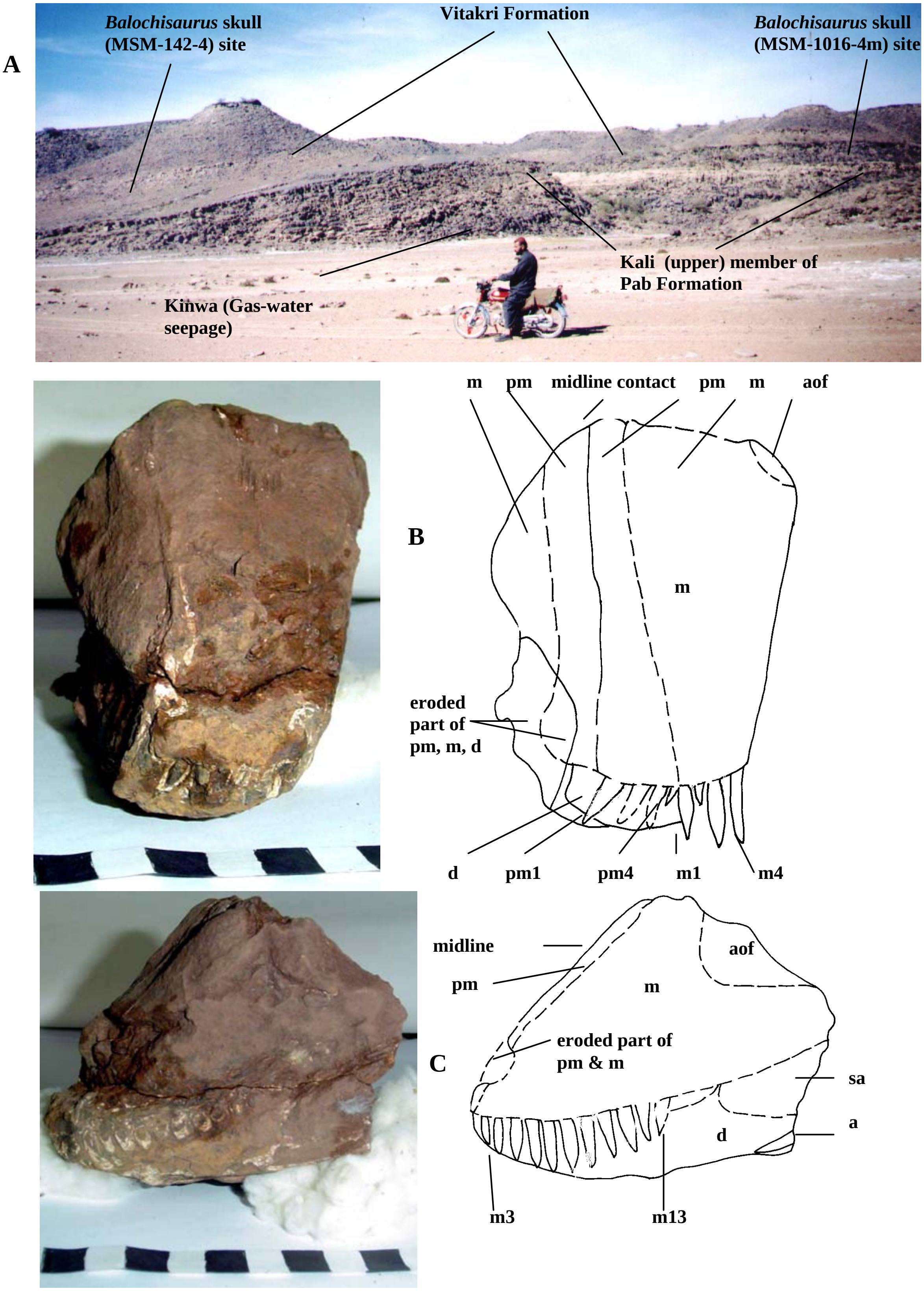

Fig. 3. A, Kinwa locality showing the *Balochisaurus* skulls sites. B, Photograph and line drawings of skull (rostrum) articulated with mandible (MSM-142-4) of *Balochisaurus.* anterior view. C, left lateral view. Scale for B and C, each black digit is 1 centimeter (cm). Abbreviation; a, angular,; aof, antorbital fenestra; d, dentary; m, maxilla; pm, premaxilla; sa, surangular. Arabic numerals following abbreviations refer to tooth position (e.g., pm 4).

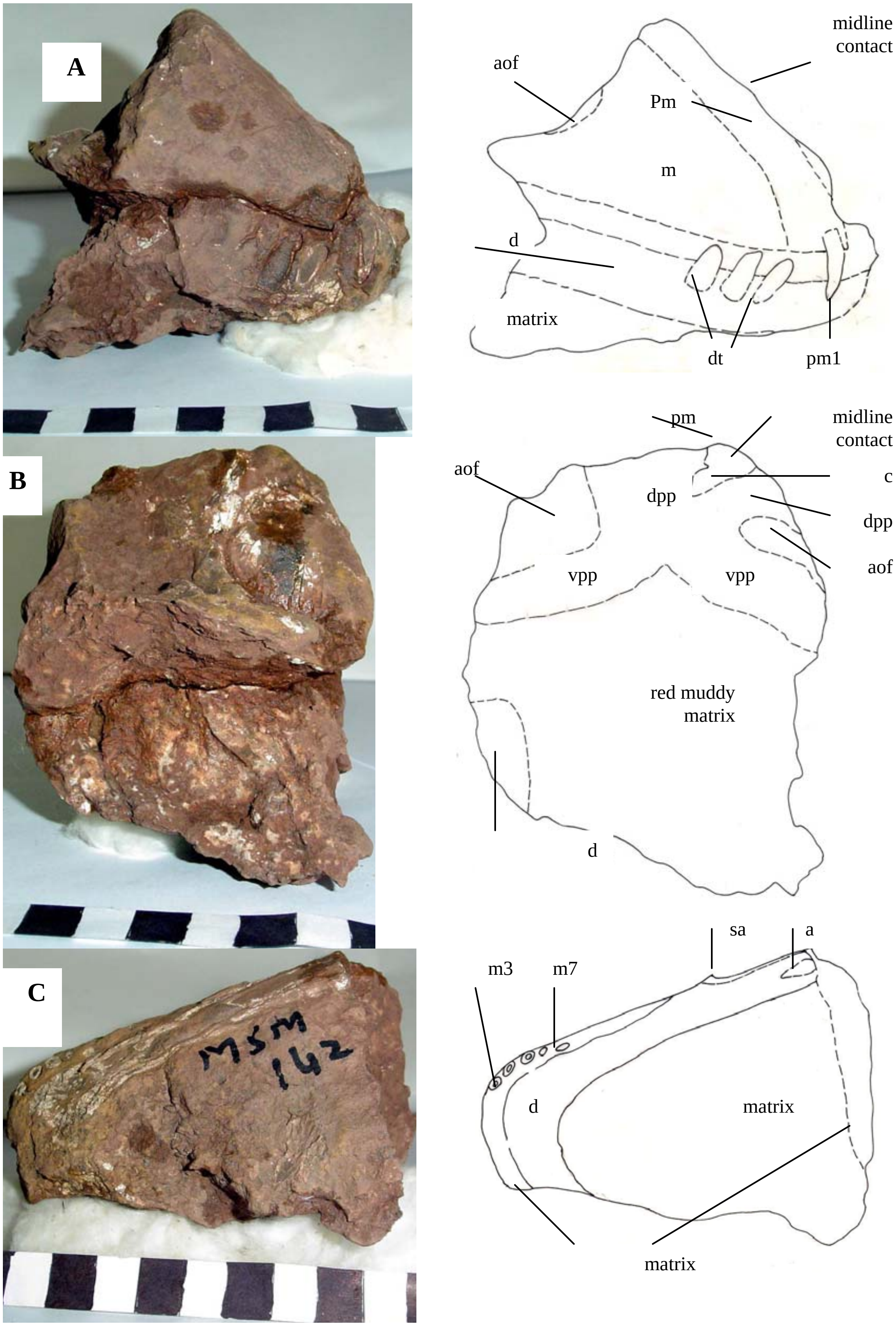

Fig. 4. Photographs and line drawings of skull (rostrum) articulated with mandible (MSM-142-4) of *Balochisaurus,* A, right lateral view; B, posterior view; C, ventral view. Scale, each black digit is1cm. Abbreviations; a, angular,; aof, antorbital fenestra; c, cavity; d, dentary; dpp, dorsal palatal process; dt, dentary teeth; m, maxilla; pm, premaxilla; sa, surangular.; vpp, ventral palatal process. Arabic numerals following abbreviations refer to tooth position (e.g., pm 1).

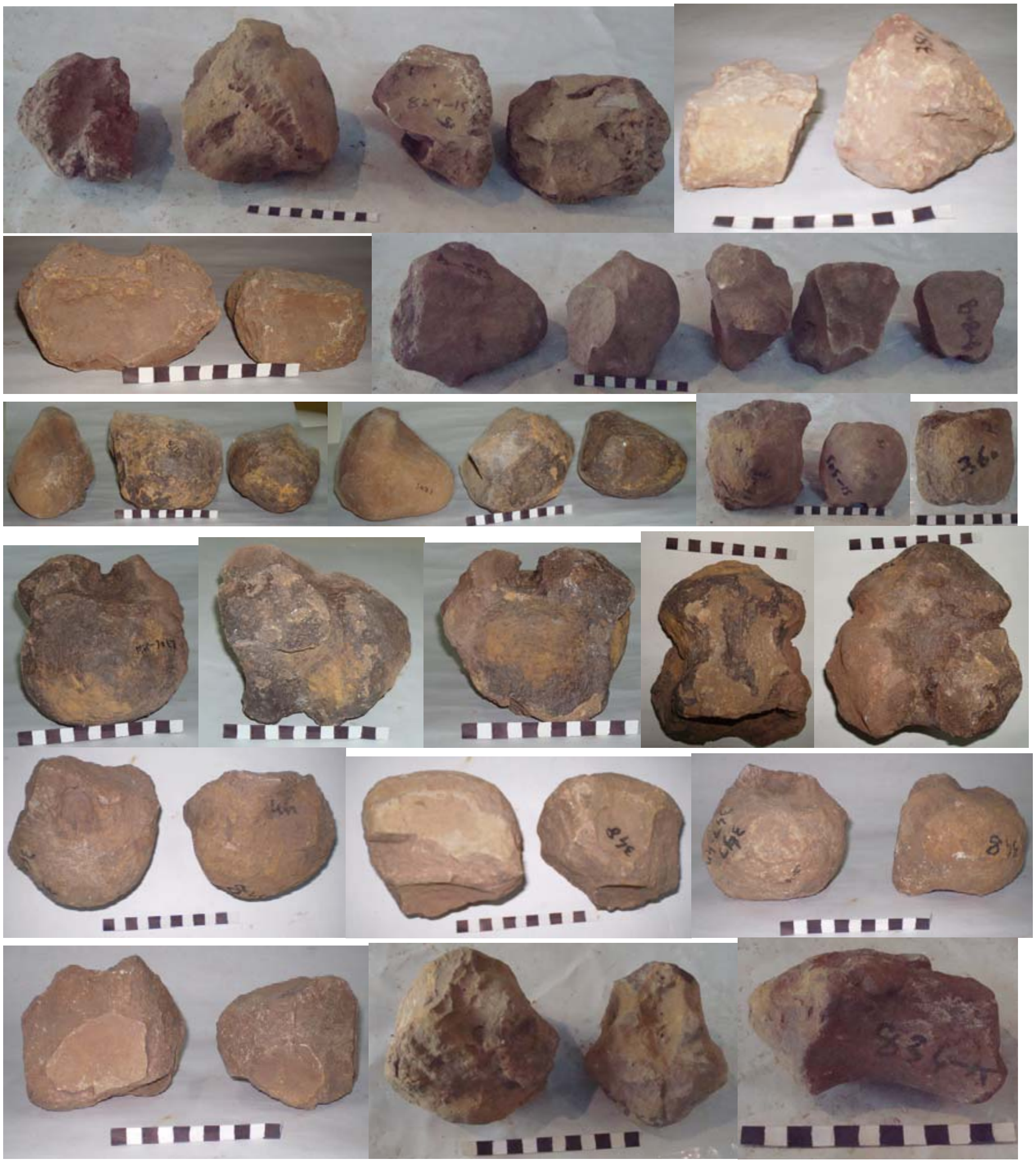

Fig. 5. First row, specimens numbers started from left to right, MSM-824-15, MSM-823-15, MSM-8-15, MSM-818-15, MSM-382-4n and MSM-381-4n presacral vertebrae; second row MSM-381-4n and MSM-382-4n presacral vertebrae; MSM-512-4, MSM-514-4, MSM-811-4 MSM-515-4 and MSM-808-4 caudal vertebrae; third row MSM-1021-4m (north), MSM-1018-4m (north) and MSM-1019-4m (north) caudal vertebrae in anterior and lateral views; MSM- 260- 15, MSM-505-15 and MSM-360-2 caudal vertebrae in anterior view; fourth row MSM-1017-4m-south midcaudal vertebra in different views; fifth row MSM-347-4n and MSM-348-4n anterior caudal vertebrae in anterior, ventral and dorsal views; sixth row MSM-347-4n and MSM-348-4n anterior caudal vertebrae in posterior view; MSM-523-7 and MSM-524-7 mid caudal vertebrae in ventral view; MSM-834-15 posterior caudal in lateral view. Scale, each black digit is 1cm.

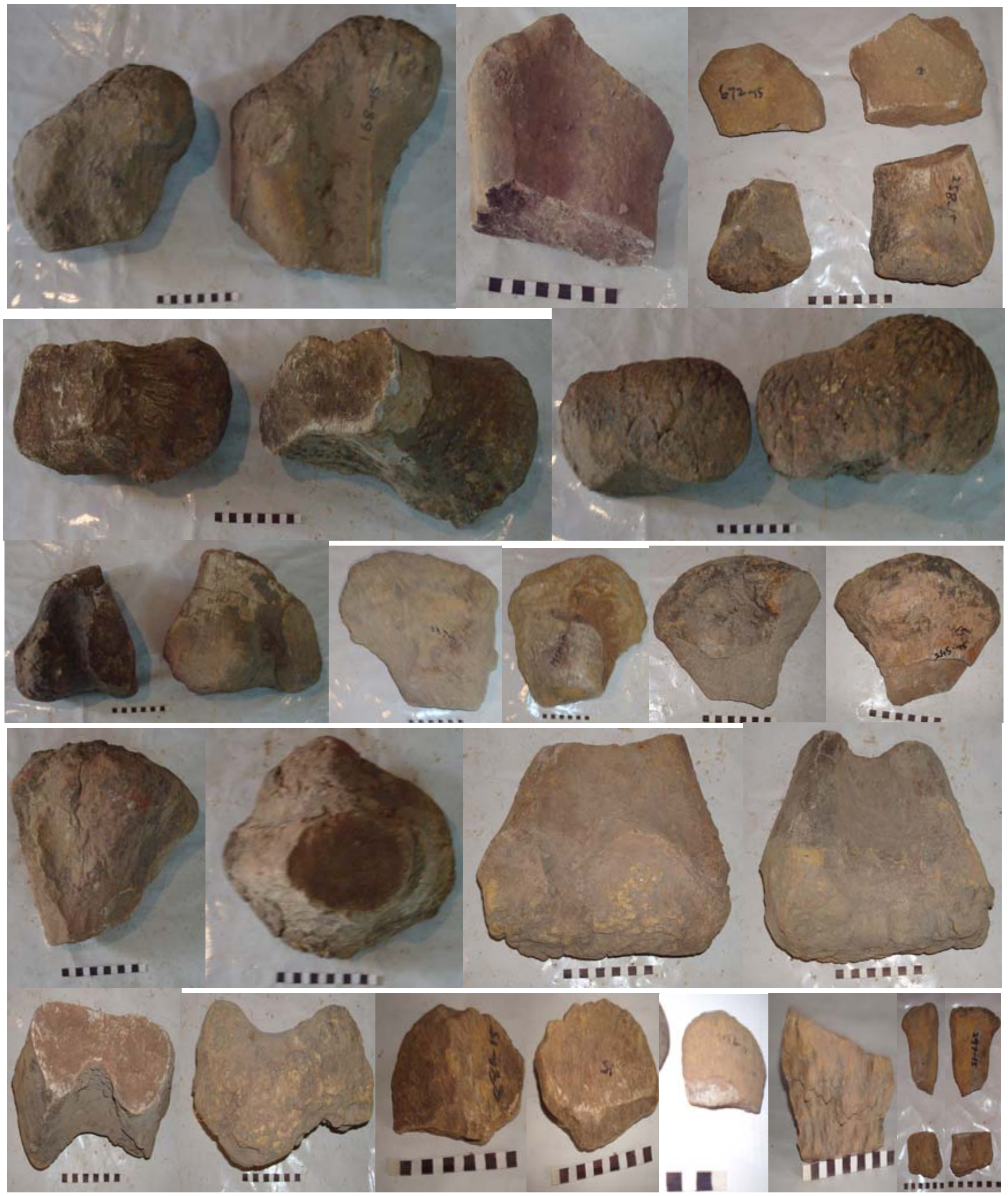

Fig. 6. First row, specimen nos started from left to right, MSM-167-15, MSM-168-15 and MSM-749-15, proximal left femora in posterior view; MSM-672-15 prox fibula (upper) and MSM-227-15 distal tibia (lower), MSM-717-15proximal humerus (upper), MSM-258-15 distal humerus (lower); second row MSM-167-15 and MSM-168-15 proximal left femora in ventral and dorsal views; third row MSM-170-15 and MSM-173-15 distal femora; MSM-237-10 proximal humerus in two views, MSM-245-15 proximal humerus in two views; fourth row MSM- 246-15 proximal left tibia stocky in lateral and dorsal views, MSM-174-15 distal humerus in anterior and posterior views; fifth row MSM-174-15 distal humerus in dorsal and ventral views, MSM-881-15 cervical rib in two views, MSM-1056-15 possibly distal rib, MSM-675-15 anterior sternal, MSM-297-15 proximal metacarpal (upper), MSM-750-15 distal metacarpal (lower) in two views. Scale, each black digit is 1 cm.

Pab Formation) were described in Malkani (2006d, 2008f). The age of Vitakri Formation is considered as the latest Cretaceous (Maastrichtian) (Malkani 2006d).

Skulls: The cranial materials such as MSM-142-4 skull **(Fig.3,4)** collected from Kinwa southern/south western site, MSM-138-4n five teeth in jaw ramus, and MSM-315-4n and MSM-314-4n skull and teeth fragments in matrix (Fig.7a) collected along with postcrania of *Balochisaurus* from northern/northeastern site of Kinwa locality, while MSM-1016-4m partial skull (Fig.7a) alongwith mid caudal vertebrae (Fig.5) of *Balochisaurus* has also been collected from mid site of Kinwa. The partial skull (MSM-142-4) is being described here. This skull resembles the teeth and alveoli characters of MSM-138-4n (Fig.7a) which belongs to *Balochisaurus* deduced on *Balochisaurus* caudal vertebrae (Fig. 5). This is the reason refer this skull to *Balochisaurus*. Articulated partial skull referable to ***Balochisaurus*** (Balochisauridae, Titanosauria), includes articulated upper and lower jaws consisting of partial left and right premaxillae, left and right maxillae, palate, left and right dentary and teeth. The found rostrum belongs to subadult animal based on the bone articulation and relative size. The teeth length and width are two third to nearly half of the adult/mature *Marisaurus*. So this animal is less in age than Alam *Marisaurus*, which is clearly adult, confirmed by cranial and postcranial materials. This rostrum represents generally long, narrow and moderate shallow shape (with 40^0 inclinations from horizontal). The external nares position is not terminal and seems to be retracted back but position unknown. The exposed part of dentary rami is pneumatic with large open internal cells, showing this partial skull is highly vascularised. The anterior portions of upper jaws are broadly arched forming U shape (Fig. 3). The teeth are long and slender. These along with other features show its assignment to Titanosauria. Wilson, (2006) stated that numerous openings in the premaxilla, anterior maxilla, and anterior dentary suggest a highly vascularized snout of Titanosauria. This interpretation is right as confirmed from *Marisaurus* and *Balochisaurus* skulls from Pakistan.

The fellow of **premaxilla** meets with each other by a dominant mid contact. At midline contact it forms a slight elevated thin belt (Fig. 3). The shape of premaxillary anterior margin seems without step or with feeble step. There are 4 premaxillary teeth. The premaxillary teeth are 1 cm to 2 cm. long and possible maximum width is 0.4 cm. The premaxillary teeth can be observed only on the anterolateral aspect of left side of rostrum (Fig. 3). Left side of rostrum is better preserved while right side of rostrum is mostly weathered/eroded, and covered by red to maroon muddy matrix. The overlapping upper jaws cover the dentary rami and the teeth of upper jaws are cemented/articulated on the lateral side of dentary ramus clearly observed on left lateral view (Fig. 3). This phenomenon is seeing like mouth closing at death. Premaxilla formed from transversely narrow main body that is greatly elongated rostrocaudally. Laterally it has a long contact with maxilla. Its each preserved fellow is 8.5 cm long, and 1 cm wide on each side measured at the cross section just behind the ending of teeth row. The both fellow are about 2 cm wide. It goes backward with about 40^0 inclinations from the anterior most point of premaxilla. The contact of premaxilla and maxilla is clear and observed on the anteriormost of the snout and on the backside of cross sectional area, but laterally and dorsally it is covered by red brown matrix. The shape of anterior portions of premaxillary and maxillary tooth rows is broadly arched forming U shape.

In **Maxilla,** there are two major parts, a horizontal tooth bearing lateral/posteroventral process and a prominent dorsal ascending process. The maxilla is a triangular element from lateral view. Its dorsal process and also lateral process bifurcate at the start of antorbital fenestra. However it is covered by matrix and it will be clear on the preparation of this specimen. The antorbital fenestra is starting at about 8 cm length from anterior most premaxilla junction. The antorbital fenestra is more than 3 cm dorsoventral height after a 2 cm start. Tentatively the antorbital fenestra started at the ending of maxillary teeth row and its position will be clear at sample preparation. The teeth have little gap less than 2 mm among each other. The larger teeth are observed in the middle of teeth row i. e., the fifth and sixth maxillary teeth. However distal parts of the most of the teeth are eroded. The length and width of longest teeth is 1.5 cm and 3 to 4 mm. The smallest teeth are less than 1 cm. Transverse width are not possible to measure due to closing of lower and upper jaws and matrix covering, however it seems to be nearly equal to width, because teeth are cylindrical/peg shape. There are 13 maxillary teeth. The maxillary teeth bearing part is 7 cm long and preserved backward portion without teeth is 4.5 cm. Backward to teeth row the upper jaw showing concavity and the lower jaw showing upward convexity (Fig. 3). Generally this rostrum is tilted towards right. There are parallel lamination on the maxilla and premaxilla.

Palatal is curved which is mostly covered and filled by muddy matrix, however on the upper part, the dorsal palatal processes are bifurcated forming cavity and connected with the premaxillary-maxillary contact. It forms a hook which support of pterygoid. The ventral palatal processes are also bifurcated and trended to wards maxilla. The left and right palatal processes are mirror images with each other but tilted due to overall tilting of rostrum. These processes are bifurcating on the dorsal and ventral parts and these are convergent only in the median part (Fig. 4). The dorsally each fellow contacted at the respective suture of maxilla and premaxilla. Then converging in the ventral mid portion and then diverging again towards lateral process of maxilla. The ventral most part of palatal is forming vaulted. The palatal characters of Marisaurus (Malkani, 2003a) and Balochisaurus have some differences. Pterygoid flange is more than 4 cm wide, and thickness is about 1 cm. The wing of pterygoid contacts opposite elements in broadsheet. Pterygoids flanges meet with each other at gentle angle from horizontal. The ectopterygoid process is robust.

Dentary depth of ramus is nearly equal and anteroventral margin shape is gently rounded (no chin). Angle between long axis of mandibular symphysis and long axis of mandible seems to be approximately 45^0. The anterior portions of dentary are broadly arched forming U shape (Fig. 4). The splenial and meclklinal canal are covered by matrix. Dentary along with preserved possibly surangular measurement is 8 cm. The best preserved impressions of three teeth of right dentary are found. The impression of central tooth (among these three teeth) is about 1.5 cm long, and 5 to 6 mm wide (Fig. 4). These teeth are exposed due to partial erosion of right maxilla and premaxilla. Tooth crowns do not overlap.

Surangular at the anterior portion is interpreted due to coronoid process i. e., the convexing upward, and the upper jaw is concaving when teeth row is finishing (Fig. 3c). Convexing and concaving occur parallel with each other for accommodation of relevant contacting jaw. It is mostly covered by matrix and will clear after sample preparation. The concavity of upper jaw may also be consistent with the anterior process of possible U shape quadratojugal.

The length of teeth is going to be increased from saggital symphysis or midline to centre of row and then decreasing up to end. Some teeth are cone forming, some show wear facet or in majority upper part is partially eroded. So the Pakistani forms represent cylindrical pencil/peg shape teeth (having conical shape tip or sharp pointed) and finger shape (blunted apex/tip may be due to wear). Long teeth preserved in the middle of jaw seem like 3^{rd} to 6^{th} while most of the tips of teeth have eroded. Teeth seem to be generally straight while middle to distal part is slightly recurving towards posterior/back side. Tooth crown cross-sectional shape at mid crown is subcircular. Maximum tooth slenderness seems to be 5. The formula applied is length divided by thickness. The premaxillary and maxillary teeth overlapped on the lateral side of denatry ramus showing the less transverse width of lower jaws than upper jaws. Teeth are long, narrow and slender. On the counting of upper jaw teeth which are total 17, the dentary may have also 17 teeth but the exposed teeth on right dentary show width of teeth is greater which represent less teeth count than upper jaw. The width of dentary teeth represents possibly 11 or slightly more than 11 teeth in lower jaw. In this way *Balochisaurus* represents possible dental formula 4, 13/11-17? The teeth row of left upper jaw seems to be complete and it gives the best information for the Titanosauria at a global level. Traditionally, titanosaurids were considered as bearing a Diplodocus-type skull (Salgado *et al.*, 1997). But now Pakistan has represented moderate incline and moderate long skull.

Vertebral elements: Vertebral elements of *Balochisaurus* were described by Malkani (2004a,2006b,c). Some remains are being described here such as the presacral vertebrae MSM-383-4n, MSM-382-4n and MSM-381-4n, MSM-347-4n, MSM-348-4n, MSM-212-4n, MSM-824-15, MSM-823-15, MSM-8-15, and MSM-818-15, (Fig. 5,7), caudal vertebrae MSM-1021-4m (north), MSM-1018-4m (north), and MSM-1019-4m (north), MSM-1017-4m-south, MSM- 260- 15, MSM-505-15, MSM-834-15, MSM-360-2, MSM-523-7, MSM-524-7, MSM-512-4, MSM-514-4, MSM-811-4 MSM-515-4, and MSM-808-4 (**Table 1),**

Table 1. The measurements of some caudal centra. Abbreviations; L1, length without articular cone; L2, length with articular cone; H1, proximal height without chevron ridge; H2, proximal height with chevron ridge; H3, distal height without chevron ridge; H4, distal height with chevron ridge; W1, proximal transverse width; W2, distal transverse width; W3, mid transverse width above; W4, mid transverse width below; W5, mid transverse width between ventral ridges; R, Ratio of mid transverse width above and below.

Specimens numbers	L1	L2	H1	H2	H3	H4	W1	W2	W3	W4	W5	R
MSM-512-4	8.0	12.0	-	-	8.0	9.9	-	12.0	-	-	-	-
MSM-513-4	9.0	14.0	-	-	10.0	-	-	13.0	-	-	-	-
MSM-514-4	7.5	10.3	-	-	8.0	9.9	-	12.0	-	-	-	-
MSM-797-4	-	-	9.0	-	-	-	8.0	-	-	-	-	-
MSM-798-4	8.3	10.3	7.3	8.0	7.1	8.1	8.0	7.7	5.5	-	-	-
MSM-517-4	-	-	-	-	-	-	-	9.0	8.0	4.5	-	-
MSM-808-4	-	-	8.0-	9.5	-	-	-	-	-	-	-	1.8
MSM-809-4	-	10.5	-	-	-	-	5.7	5.5	4.3	4.3	-	-
MSM-810-4	7.5	-	6.7	-	5.5	-	9.5	-	8.0	4.5	-	1.0
MSM-811-4	-	-	9.0	10.5	-	-	-	7.3	4.05	4.0	-	1.8
MSM-260-15	8.5	12.5	-	-	9.2	10.2	-	11.0	10.0	7.7	-	1.3
MSM-503-15	-	-	-	-	10.5	-	-	11.5	-	-	-	-
MSM-504-15	-	-	-	-	8.5	-	-	8.5	-	-	-	-
MSM-505-15	7.5	10.5	-	-	9.0	10.1	7.8	10.1	8.5	4.7	-	1.8
MSM-506-15	-	-	7.5	-	-	-	-	-	-	-	-	-
MSM-833-15	10.0	13.0	8.0	-	-	-	9.0	8.5	-	-	-	-
MSM-834-15	8.0	11.0	5.3	-	4.9	5.4	6.0	6.0	-	-	-	-
MSM-153-16	-	-	-	-	-	-	6.7	6.7	-	-	-	-
MSM-360-2	9.0	11.5	8.0	-	-	-	8.9	9.0	8.5	5.3	-	1.6
MSM-520-2	9.0	13.0	8.3	8.5	-	-	9.0	8.2	6.2	7.2	-	-
MSM-523-7	-	-	-	-	-	8.7	9.7	10.7	8.0	4.0	-	2.0
MSM-524-7	-	-	-	-	-	7.4	-	9.0	7.5	4.0	-	1.1
MSM-525-9	-	-	9.3	-	-	-	9.3	-	-	-	-	-
MSM-526-9	6.5	10.5	-	-	6.3	-	6.5	5.8	-	-	-	-
MSM-01-19s	8.0	13.0	-	-	7.5	-	12.0	11.5	-	-	-	-

cervical rib MSM-881-15, cervical neural spine MSM-324-4n, neural spine with post zygapophyses and prespinal laminae of dorsal vertebra MSM-323-15, mid rib of dorsal vertebra MSM-531-15 and chevron MSM-313-4n (Fig.7). The Cervical centra are broad, long and opisthocoelous and constricted (have almost flat and slightly concave ventral surface because anterior cone and posterior articular surfaces are trending to lower level than central surface of centra). The dorsal vertebrae have three morphologies like short and broad centra, short and circular centra, and tall and relatively long. The broken dorsal vertebrae represent the camellae/spongy/ pneumatic texture and there is no hyposphene-hypantrum articulation in any of the collected dorsals. The sacral centra are short, broad and have a ventral keel. The detail descriptions of sacral and presacral vertebrae are mentioned in Malkani (2006c). All the caudal vertebrae are strongly procoelous (except anteriormost and distalmost caudals). Both the height and width of caudal centra reduces much backward with relative to their length, which reduces less. Anterior caudals are broad while the mid caudals are squarish to slightly broad and posterior caudals are long and cylindrical with anterior circular articular and posterior squarish to circular posterior articular region. The chevron facets are not found on the anterior most caudals and posterior caudals, while located in the remaining anterior and middle caudals. The neural arch is situated on the anterior half of the caudal centra. The prezygapophyses are rod like while post zygapophyses also have lateral small surface for attachment. The middle and posterior caudal spines are laterally compressed and seem to be directed posteriorly. Prominent rib facets (transverse processes) occur which seems like tapering in anterior caudals. Trispinous distalmost caudal centrum specimens like MSM-325-15 (Mari Bohri Locality) belongs to *Balochisaurus* (Malkani, 2008f). This type of tail of titanosaur from Pakistan is unique among World. It seems to be robust and relatively short which may act for multipurpose like good defending tool for its foe like *Vitakridrinda* and *Pabwehshi* etc, balancing body as third support during foraging from tall tree, and mating.

Appendicular elements: The most representative appendicular elements are being briefly described.
Scapula: MSM-746-7 mid scapula (Fig.7). The mid scapula has D shape cross-section and its ventral concave side also have ridge or ventral crest located on side. The angle from mid to distal blade show that the distal scapula of *Balochisaurus* (and possibly *Marisaurus)* is not deflected laterodorsally i. e., it is straight or slightly deflected medially and also not expanded in the lateroventral side of mid scapular blade, while the scapula of *Pakisaurus* (Pakisauridae) is deflected laterodorsally and expanded in the lateroventral side of mid scapular blade.

Coracoid: MSM-752-9 corocoid right (Fig.7). The preserved specimen has the glenoid and its vicinity area. The coracoid plate is maximum thick at the glenoid area and become thin abruptly in the other area. The corocoid glenoid area is at the same level as plate on one side but elevated or raised on another side of plate. Over the glenoid area, there is a thickening of the bone which sharply falls on the plate and slightly falls on the rugose area for the articulation with scapula.

Sternal Plate: MSM-675-15 anterior sternal (Fig.7b). The anterolateral edge is maximum thick and has anteroventral crest and becoming gradually thin as proceeding posterior and medial directions. There are rugosities on the anterior, anteolateral, anteromedial of anterior of sternal plate. These rugosities show connectin with the scapular corocoid region and other fellow. The plate is slightly concave on the ventral and dorsal sides. The anterolateral part is thick and subrounded. From this thick corner the thickness is consistently reduced in the medial side. The anterior end is thick, which extends over the ventral side, starting at the anterior end of the bone, backward for about 8/10 cm.

Fore limbs: It is represented by the humerus, ulna, radius and metacarpals.

Humerus: MSM-258-15 distal humerus; MSM-717-15 humerus, MSM-245-15 proximal humerus; MSM-174-15 distal humerus and MSM-174-15 distal humerus (Fig.6); MSM-380-4n, MSM-377-4n, MSM-379-4n, MSM-438-4n, humerus parts (Fig.7). The humerus is expanded at proximal and distal ends. The anterior view of the distal humerus have prominent ridge, and posterior part is divided well in to two condyles. Humerus having a continuous ridge (convexing part) on the posterior view of humerus starting from head to downward may be running up to constricted middle part of humerus. Proximal humerus has head and represents deltopectoral crest which may be slightly twisted. The proximal humerus is slightly rugose while distal humerus has intense rugosities. Humeral midshaft cross section is elliptical, with long axis oriented transversely. The supracondylar ridges are prominent forming well developed depression for the adjustment of prominent olecranon process. Radial and ulnar condyles are small and distinct on anterior side and a broad groove for the adjustment of prominent olecranon process.

Radius: MSM-344-4n proximal radius (Fig.7).Proximal end is elongated sub oval type. The proximal part show slight concavity or depression on proximal view. The proximal end is expanded and has has pointed expansion directed medially. Radius shaft is nearly circular, and seems to be only oval when attaching with the medially tilted distal ends.

Ulna: MSM-252-9 distal ulna (Fig.7). The proximal ulna (MSM-78-15; Malkani 2006b, fig. 20a,b) is being assigned to *Balochisaurus*. It is rugose and bears a prominent olecranon process. The proximal ulna represents a triradiate structure. The ulna is gracile. There is a marked concave depression on the proximal lateral side to cradle the head of radius. It has also depression on the medial side also. The posterior side have slight depression and almost smooth. The ulna gradually tapers toward distal end which is subovate in outline and smaller than the proximal end. Distally the shaft has marked depression for the reception of distal radius. Ulna has well developed olecranon process. Relative lengths of Ulnar proximal condylar processes are unequal. It is three face elements. The medial face is broader one. On the proximal half of the bone this face is concave. On the junction with rest of the faces it forms acute angles. The anterolateral face is concave in the proximal region, losing this character at the distal end.

Metacarpals: MSM-287-15 and MSM-750-15 metacarpals (Fig.6). Metacarpals are elongated and triangular and have rugose articular proximal surfaces. Distal condyle shape is undivided and has no articular rugosities. A proximal and distal end is expanded with triangle shape.

Ilium: MSM-166-15 acetabulum (Fig.7). Pelvic girdle is represented by partial acetabulum. It includes the glenoid with large pubic peduncle condyle (broken) and short and laminar ischium peduncle. Ventrally the acetabulum is long and oval and bears parallel ridges. Up of the pubis peduncle a robust subrounded broken bone is located which may join to the preacetabular process. The pubic peduncle is large and subovate or flat and D shape. In contrast the ischium peduncle is feeble. The acetabulum forms the embayment for the reception and movement of femur heads. The broken part of ilia represents the parallel spongy/pneumatic texture with large open internal cells. Dorsal margin of the ilium is curved and thin and commonly damaged.

Hind limbs: It is represented by the elements like partial femora, tibiae, fibulae and metatarsals.

Femur: MSM-190-4n left full femur; MSM-167-15, MSM-168-15 and MSM-749-15 proximal left femora; MSM-170-15, MSM-173-15 distal femora (Fig. 6), MSM-190-4n, MSM-192-4n a pair of distal femora (**Fig.7)**; MSM-378-4n, MSM-270-4n femur sections **(Fig.7)**. These femora are stocky and have no supracondylar-elongated ridges. In contrast to this type, the slender type has supracondylar-elongated ridges with prominent rugosities starting from distal tibial and fibular condyles running towards mid constricted portion (Malkani 2008f). The length of femur (MSM-190-4n) is about 85-90 cm. Proximal femora are beveled one third medially. Distal end is bifurcated in two condyles as tibial and fibular condyles. The tibial condyle is relatively more deep than fibular condyle while the fibular condyle is relatively more wide than tibial condyle. The tibial condyle is wheel like. The fibular condyle is posteriorly divided in two sub condyles forming fibular condyle and another tibiofibular condyle. Femoral shaft is elliptical. It may become subcircular to circular in the minimum transverse diameter, relatively close to distal condyle than proximal condyle. Femora show a posterior ridge starting from the end of greater trochanter running feebly to the mid constricted part. The head is rises more than greater trochanter and also more thick than greater trochanter. There is no notch in between the head and greater trochanter. The depression in between the distal condyles is shallow.

Tibia: MSM-227-15 distal tibia, and MSM- 246-15 proximal left tibia stocky (Fig.6); MSM-346-4n distal tibia stocky and MSM-345-4n distal tibia stocky **(Fig. 7)**. The tibia is broad and thick proximal surface and oval shape distal surfaces. Tibia cnemial crest projects laterally. Tibial distal posteroventral process is broad transversely **(Fig. 7)**.

Fibula: MSM-672-15 prox fibula proximal fibula have well marked medial scar for attachments of tibia which is deepening anteriorly. Fibula has flattened proximal end. It has a medial diagonal ridge.

Fig. 7. A, first row, specimens numbers are from left to right, MSM-190-4n and MSM-192-4n a pair of distal femora in ventral view, and MSM-344-4n proximal radius; second row MSM-344-4n proximal radius in dorsal view, MSM-138-4n five teeth in jaw ramus in two views, MSM-315-4n and MSM-314-4n skull and teeth fragments in matrix, MSM-1016-4m partial skull in lateral and posterior view; third row MSM-323-15 neural spine with post zygapophyses and prespinal laminae of dorsal vertebra and MSM-313-4n chevron in three views; B, upper row MSM-752-9 corocoid right, MSM-675-15 sternal, MSM-166-15 acetabulum, MSM-322-15 proximal rib of dorsal vertebra, MSM-746-7 mid scapula; second row MSM-324-15 cervical neural spine, MSM-323-15 dorsal neural spine, MSM-313-4n chevron, MSM-531-15 mid rib of dorsal vertebra, MSM-252-9 distal ulna; third row, MSM-381-4n cerv, MSM-212-4n cerv/dorsal, MSM-382-4n cerv, MSM-383-4n cervical, MSM-344-4n prox radius: C, first column MSM-190-4n left full femur; second column MSM-346-4n distal tibia stocky, MSM-345-4n distal tibia stocky, MSM-378-4n and MSM-270-4n femur sections, MSM-192-4n distal femur; third column MSM-380-4n, MSM-377-4n, MSM-379-4n and MSM-438-4n, humerus parts. Scale, each black digit is 1 cm.

Metatarsals: The metatarsals are arranged in semicircular fashion diverging outward and downward in contrast to the vertically oriented metacarpals as revelas by footprints of titanosaurs with pad like heel (Malkani, 2007a; 2008f). According to McIntosh (1990) the metatarsal V is shorter with characteristically much larger proximal than distal ends. The first three digits bore claws of decreasing size but in Pakistani titanosaurs footprint these are nearly equal. It is possible there is no claw on digit IV and V, may be deduced from the footprint of titanosaurs from Pakistan (Malkani, 2007a; 2008f).

Osteoderms from Pakistan

Four types of dermal armour bones, which are lacking distinct pit patterns as in crocodilians, are referred to *Pakisaurius*, *Marisaurus* and *Balochisaurus*. The armour plates like MSM-83-16 (Malkani 2003b; fig.2), and MSM-1035-16 (Malkani, 2008f; fig.7a) from Top Kinwa locality were referred to *Marisaurus*, MSM-85-4 (Malkani, 2003b; right side specimen of fig. 3,4,5) from Kinwa locality was referred to *Pakisaurus*, and MSM-84-7 (Malkani, 2003b; left side specimen of fig.3,4,5) is being referred to *Balochisaurus*. The discovery of larger and smaller osteoderms from Pakistan provides a further opportunity for evolutionary history and correlation with the armor bones already discovered from Madagascar, Argentina, Brazil, France, Malawi, Romania and Spain.

Wide gauge skeletal morphology of *Balochisaurus* (Balochisauridae) from Pakistan

Sauropods have narrow and wide gauge locomotion style. The Pakistani titanosauria is a wide gauge with two varieties like less wide gauge and more wide gauge, which is confirmed by the collected fossils of dinosaurs from Pakistan. The distal scapula in some Pakistani taxa is deflected laterodorsally (assigned to Pakisaurus) creating more wide gauge movements while in some other Pakistani taxa the distal scapula is straight or slightly inclined medially (assigned to *Balochisaurus*) with less wide gauge movements (Malkani 2008f).

New remains of *Vitakridrinda* (Abelisauridae, Theropoda) found from Pakistan.

Its **holotypic remains** are MSM-155-19 a rostrum (Malkani, 2006b,fig. 13; Malkani 2006e, figs. 3,4,5,6; and here Fig.8,9); MSM-59-19, MSM-60-19 a pair of left and right proximal femur (Malkani 2006b, fig. 7-10, 16a), MSM-61-19 basioccipital condyle alongwith partial braincase (Malkani 2006b, fig. 14b, 15a,b) and MSM-62-19 a tooth (Malkani 2006b, fig. 16a) were collected from the central Alam Kali Kakor locality. The holotypic rostrum is very high and narrow forming anterior most junction of premaxilla like V shape. This rostrum bears the thickened elements. The external nares are not wholly enclosed by premaxillae but on the posterodorsal part the nasal flanks enclose the external nares, however it will be clear after removing matrix. The braincase MSM-62-19 show basipterygoid processes are close each other i.e., not widely separated as it is reported in *Abelisaurus*, and the basioccipital condyle is long and thick. *Vitakridrinda* belong to large Abelisauridae Carnosauria.

The **Referred materials** of large bodied *Vitakridrinda* were found from Alam, Bor, Sangiali, Shalghara, and Mari Bohri localities which were described and presented at the occasion of fifth Pakistan Geological Congress Islamabad (Malkani 2004a). Its materials were described and figured formally published in Journal of Applied and Emerging Sciences (Malkani, 2006b). Its referred remains are MSM-53-2, MSM-54-2, and MSM-55-2 three fragmentary but seems to be associated vertebrae collected from Bor Kali Kakor locality; MSM-56-1 one fragmentary caudal vertebra from Sangiali Kali Kakor locality; MSM-58-15 one fragmentary caudal vertebra from Mari Bohri locality; and MSM-57-3 one fragmentary presacral vertebra from Shalghara Kali Kakor locality (Malkani 2006b, fig.5-8). The correct arrangement of specimen's numbers in the caption of fourth row of fig. 5-8 of Malkani 2006b is MSM-57-3, MSM-58-15, MSM-53-2, MSM-54-2, MSM-55-2, MSM-56-1, MSM-59-19 and MSM-60-19 of *Vitakridrinda sulaimani.* It is also necessary to mention that the vertebrae of *Vitakridrinda* are amphicoelous which are misspelled as procoelous in Malkani 2006b. Here partial presacral centra MSM-706-19 and MSM-765-19; articulated elements of pes MSM-303-2; cross section of leg bones MSM-1041-2, MSM-1042-4, MSM-1043-16 and MSM-1044-16; partial vertebrae MSM-

1040-16, MSM-780-2, MSM-1048 and MSM-282-15; proximal femur or nodule MSM-1049-K; mid cross section of femur or nodule MSM-1057-K; part of peripheral bone of leg section MSM-1059; thick cross section of femur MSM-984-2; distal femur cross section MSM-1039-19; peripheral limb bone with hollow MSM-1027-2; and pieces of coprolites MSM-1050, MSM-1051, MSM-1052, MSM-1053 and MSM-1054-2 are being referred (Fig. 8a,b,c). All these holotypic and referred specimens are housed at the Museum of Geological Survey of Pakistan, Quetta.

Vertebrae: The articular surfaces are amphicoelos and expanded, while the mid centra are relatively reduced to about one half. Further the central core of centrum has sub circular hollow. This hollow also shows some network of fibrous bone **(Fig.8)**. One vertebra of *Vitakridrinda* (from Malkani 2006b) has chevron facets.

Appendicular elements: A section of femur (MSM-1039-19; Fig. 8) is collected from the same site as holotype femur, so it is possible this section belongs to holotypic femur because of same occurrence and size matching. This section has cavity like hollow on one side but the other possible ventral side has fibrous bone network in the hollow representing close approach to fibular and tibial condyles. Further a thick section (MSM-984-2) of femur represents large body size of *Vitakridrinda*, and many other elements are found (Fig.8)

A foot/pes: One foot/pes of theropod found from the latest Cretaceous Vitakri Formation of Bor Kali Kakor Locality of Vitakri area, Barkhan District, Balochistan. This claw is found with the association of 3 vertebrae of *Vitakridrinda* and a dead skeleton of *Marisaurus* (Balochisauridae, Titanosauria). It seems that adult *Vitakridrinda* along young one has come to eat this prey or the adult *Vitakridrinda* made prey after interaction and then the young one also came to eat. However what is inactual, the partial skeleton of adult *Marisaurus*, adult *Vitakridrinda* and one young *Vitakridrinda* has been found associated in the central site of Bor locality. The foot seems to be birdlike tridactyl. The phalanges and unguals are robust. This foot/pes belongs to right hind limb. There are three preserved digits. The digit I has partial metatarsal with two phalanges and one claw. The digit II has preserved partial metatarsal and possible three or four phalanges and one claw. Some elements of digit III is preserved and have some impressions. The claw is three time long than its width. The length of *Pakisaurus* ungual is one and half time than width. In this way the length and width ratio is 3 in this theropod while in *Pakisaurus* (Pakisauridae, Sauropoda) is 1.5. The claw is slightly concave in the ventral side. The phalanges are also elongated having well developed expanded articular surfaces/condyle

The bite impressions which are represented by the puncture, groove, and gash line on right and left sides, and embedded teeth of its combatant on left side of the snout of this theropod. The morphology of bite mark and puncture represents that the found rostrum-bearing animal faced off, and its fellow combatant snapped by own upper and lower jaw rami to the front of its conspecific foe **(Fig. 8)**. It represents the jaw-gripping behavior **(Fig. 8)** accounts for peculiar bite marks found on the sides of snout. The bite pattern implies that the combatants maintained their heads at the same level during this confrontation. The rostrum of *Vitakridrinda* clearly show severe damage created by its conspecific foe and consequently to a death. The possible four teeth of its fellow combatant are embedded on and near the line of bite and puncture **(Fig. 8)** and one tooth are embedded off the bite line. One major tooth having anteroposterior length 2.25 cm and transverse width 1 cm, and second tooth having anteroposteriorly length 1.4 cm and transverse width7 mm, third tooth having anteroposterior length 1.2cm and width 5mm, and fourth smaller tooth are found on the bite line. One another tooth having anteroposterior length 8mm and width 7mm is located off the bite line. The muddy matrix found from this rostrum site host some teeth of *Vitakridrinda*, and among these teeth, one tooth having anteroposterior length 1.7 cm and width 7 mm. The bite fracture is open and deep in the right side of snout which represents the strong stress. Due to wide fracture, no embedded teeth are found, only teeth bite impressions are clear. In this way on the opposite side (left side), the five teeth are embedded on and around the bite line,

Fig. 8. A, MSM-303-2 pes in two views; B, first column MSM-1044-2, MSM-1043-4 and second column MSM-1041-16, MSM-1042-16 leg bones in two views; C, upper row 706-19 and MSM-765-19 vertebrae in two views; MSM-1040-16, MSM-780-2, MSM-1048 and MSM-282-15 partial vertebrae; MSM-1049-K proximal femur or nodule, MSM-1057-K midcross section of femur or nodule, MSM-1059 parts of peripheral bone of leg section, MSM-984-2 thick cross section of femur; lower row MSM-1039-19 distal femur cross section dorsal and ventral views taken transversely and anteroposteriorly; MSM-1027-2 peripheral limb bone with hollow, MSM-1050, MSM-1051, MSM-1052, MSM-1053 and MSM-1054-2 pieces of coprolites; D,E, models of confrontation representing snapping scenarios; F, Photo and line drawings of holotypic rostrum of *Vitakridrinda* shows bite line and puncture. Abbreviations; en external nare, m maxilla, pm premaxilla, n nasal. Scale for A, B, C and F each black digit is 1cm.

which reveal that force was strong but situation for stress was not suitable for fracture, ultimately teeth are broken on the reaction by affected fellow combatant. On the reaction of affected combatant, there was no time or possibility to out the teeth, consequently result was broken of teeth happened. These remain as (souvenir) embedded teeth of fellow combatant. The bit pattern show the snapping of combatant by its massive teeth of right side jaws (Fig. 8) instead of snapping from the front, however mouth opening limit convey the griping with massive teeth of left side lower and upper jaws Fig. 8).

Confrontation scenario between two *Vitakridrinda* deduced from its holotypic rostrum

A continuous elongated puncture is observed on anterior and both sides of snout of *Vitakridrinda* (Fig. 8f) represents a long puncture and bite mark on both sides of premaxilla and maxilla. The puncture trend represents that the right side bite created by lower madibular/dentary ramus, and the left side bite created by upper jaw. Tooth bite impressions are also observed on right side of snout. The puncture is generally trending anteroposteriorly, located in the lower half and just below the boundary of preserved half snout. Left lateral view of rostrum of carnivorous *Vitakridrinda* **(Fig. 9a)** represents the bite mark and puncture in premaxilla and maxilla. Four or five embedded teeth of its conspecific combatant foe are fixed in the maxilla only. The bite mark and puncture depth is relatively less than the other (right) side. The embedded 4 or 5 teeth belong to the upper jaw/ maxilla of its combatant foe. The preserved length of bite line is about 9 cm on left side of snout while depth of bite is feeble. The puncture line is generally trending anteroposteriorly, located in the lower half and just below the boundary of preserved half snout and becoming downward as proceeding posteriorly. Right lateral view of rostrum of carnivorous *Vitakridrinda* **(Fig. 9b)** also represents the bite mark and puncture in premaxilla and maxilla. The bite mark and puncture depth is relatively deep than the other (left) side. The preserved length and width of puncture is about 9 cm and 2.5 cm respectively on right side of snout, widening on the back and thinning a forward. The puncture is trending anteroposteriorly, located in the lower half and just below the boundary of preserved half snout. Posterior view of rostrum of carnivorous *Vitakridrinda* **(Fig. 9c)** represents the bite mark and puncture in maxilla.

Trackway sites provide information on animal biomechanics (Thulborn, 1989), speed, herding or grouping behavior (Currie, 1983; Currie and Dodson, 1984; Currie, 1998), possibly migration (Currie, 1989) and interaction behavior. Monospecific or low diversity bonebeds demonstrate social herding (Currie and Dodson, 1984) and protection of young. Egg localities reveal communal nesting strategies (Horner, 1982), and nest protection or incubation (Dong and Currie, 1996: Norell *et al*., 1995). Paleopathology, the study of ancient disease processes, dentopathy and osteopathy can provide direct, compelling insights into some aspects of dinosaur behavior (Rothschild and Tanke, 1992). Aggressive interaction behavior can be studied from Middle Jurassic trackways of titanosaurian sauropod confronted by a large bodied (possibly abelisaurian, the ancestor of *Vitakridrinda*) theropod track (Malkani, 2007a, 2008f). Aggressive behavior among large theropod conspecifics has been postulated in allosaurids (Molnar and Farlow, 1990) and tyranosaurids (Molnar, 1991), but due to present discovery abelisaurids are included. The published records of cranial trauma or pathology in large theropods are sparse (Tanke andCurrie, 1998), but this rostrum of ***Vitakridrinda*** reveals the story of confrontation.

Meat eating dinosaurs may often have been as ill- tempered as modern crocodiles (Farlow, 2000). Interaction among individuals of the same theropod species may at times have been fatal (Farlow, 2000). The bite marks consist of gouges and punctures on the sides of the snout, on the sides and bottom of the jaws, and occasionally on the top and back of the skull of *Tyrannosaurus*. Interpreting these wounds, Tanke and Currie (1998) reconstructed how these dinosaurs fought. They believe that the animals faced off, but primarily gnawed at one another with one side of their complement of massive teeth rather than snapping from the front. The workers also surmised that the jaw-gripping behavior accounts

Fig. 9. Photo and line drawings of holotypic rostrum of *Vitakridrinda* (Abelisauridae, Theropoda) in left lateral (A), right lateral (B) and posterior (C) views showings bite puncture and embedded teeth of its combatant.

Abbreviations; dpp dorsal palatal process, en external nare, m maxilla, mb medial bar, mic maxillary internal chamber, pm premaxilla, n nasal, vpp ventral palatal process. Scale, each black digit is 1cm.

for peculiar bite marks found on the sides of tyrannosaur teeth. The bite pattern implies that the combatants maintained their heads at the same level throughout a confrontation. Based on magnitude of some of the fossils wounds, *T.rex* clearly showed little reserve, and sometime inflicted severe damage to its conspecific foe. The usual subjects-food, mates, and territory may have prompted the vigorous disagreements among tyrannosaurs (Erickson, 2000). One tyrannosaur studied by Tanke and Currie (1998), sports an embedded tooth in its jaw, perhaps left by a fellow combatant (Erickson, 2000). But the present discovery of *Vitakridrinda* snout represents 5 embedded teeth of its fellow combatant. By this discovery, Pakistan has entered among those countries of worlds which provide the paleopathological traces in dinosaur bones,and in this regard Pakistan stand first in Asia.

According to null hypothesis that the nonavian theropod dinosaurs were solitary hunters or at most foraged in loose association. Since the 1969 description of *Deinonychus antirrhopus* Ostrom (1969) cooperative pack hunting, highly gregarious, and mammal like behavior for this species and subsequently for many other nonavian theropods (e.g., certain theropod dominated fossil assemblages, preserved bite mark injuries on some specimens, and the preponderance of theropod trackways at some sites) has attained wide acceptance. The present fossil of *Vitakridrinda* theropod from Pakistan verify the theory of Roach and Brinkman (2007) regarding nonavian theropods which were likely more solitary in nature, engaging in agonstic, ora like feeding, aggregations and interacting with their conspecifics in ways that were much more contentious, combative, cannibalistic and diapsid like than has been widely believed.

The intraspecific predation in nonavian theropods suggests that predatory theropods foraging within loosely bound aggregates would at times fight aggressively over a carcass once a kill had been made (Roach and Brinkman, 2007). This fact seems to be true by the finding of the carcass of *Vitakridrinda* Malkani 2006b,e (with embedded teeth of conspecific foe on its rostrum) with the carcass (partial skull associated with postcrania) of adult *Marisaurus*. Its occurrences with titanosaur dead body suggest that the theropods have come to *Marisaurus* to prey or to eat after its death. And subsequent fighting of *Vitakridrinda* with other conspecific foe has preserved from the about 70 million years ago. The oval to D shape of embedded teeth represents its foe as conspecific because *Vitakridrinda* bears oval to D shape of teeth. However the diameters of teeth of conspecific foe of *Vitakridrinda* were more and that is the reason I argued the conspecific foe to be more in age than *Vitakridrinda*. Further the fighting between *Vitakridrinda* and its conspecific foe seems to be a matter of food. However at that time when delicious food was available, then it may be a matter of courtship/mating. Whatever the motivation behind the fighting, the fossil record of *Vitakridrinda* rostrum demonstrates the serious confrontation between theropods which resulted the death of *Vitakridrinda*. This is the first rostrum in global World which has bite mark, puncture, teeth impressions and 5 embedded (souvenir) teeth of its combatant which reveal the story of confrontation between *Vitakridrinda* and its fellow combatant. This rostrum provides further opportunity for correlation, phylogeny, paleobiogeography, behaviors like fighting, scavenging, predatory and interaction among intra or interspecific theropods.

4. Conclusions

So far about 30 localities of archosaurs (dinosaurs and crocodiles) are found from the Mesozoic of Pakistan. The *Balochisaurus* and *Vitakridrinda* remains have been found from many localities of the latest Cretaceous Vitakri Formation in Sulaiman basin of Pakistan. *Balochisaurus* (along with other genera of dinosaurs) fossils provide new insights in to skull and postcranial morphology. Sulaiman basin of Pakistan show richness in cranial and postcranial remains of dinosaurs for further exploration and studies.

References

Bonaparte, J.F. and R.A. Coria. (1993) Unneuoy gigantesco sauropodo titanosaurio de la formation Rio Limay (Albiano-Cenomanio) de la provincial del Neuquen, Argentina, *Ameghiniana*, (**30**): 271-282.

Bonaparte, J.F. and F.E. Novas (1985) Abelisaurus comahuensis, n.g., Carnosauria del Cretaccico tardio de Patagonia. *Ameghiniana*, (**21**): 259-265.

Currie, P.J. (1983) Hadrosaur trackways from the Lower Cret. of Canada. *Acta Paleontol. Polinica* (**28**): 63-73.

Currie, P.J. (1989) Long distance dinosaurs. *Nat. Hist*. (**6**) 60-65.

Currie, P.J. (1998) Possible evidence of gregarious behavior in Tyrannosaurids. *Gaia* 15.

Currie, P.J. and P. Dodson. (1984) Mass death of a herd of ceratopsian dinosaurs, in Reif, W. E. and Weishphal, F. (Eds.), *third symposium on Mesozoic Terrestrial Ecosystems*, short papers, Tubingen, 61-66.

Curry Rogers, K. (2005) Titanosauria, A phylogenetic overview. In K. A. Curry Rogers, J.A. Wilson (eds), *Sauropod Paleobiology*. University of California Press, Berkeley, 50-77.

Dong, Z.M. and P.J. Currie. (1996) On the discovery of an oviraptorid skeleton on a nest of eggs at Bayan Mandahu, Inner Mongolia, People's Republic of China. *Can. J. Earth Sci.* (**33**): 631-636.

Erickson, G.M. (2000) Breathing life in to *Tyrannosaurus rex* in Gregory, S. P, (editor) *The Scientific American Book of Dinosaurs*, St. Martin's press, New York, 424pp.

Falconer, H. (1868) Memorandum of two remarkable vertebrae, sent by Dr. Oldham from Jubbalpur-Spilsbury's bed. *Paleontological memoirs and Notes of the late Hugh Falconer* (**1**): 418-419.

Farlow, J.O. (2000) "Tracking Dinosaur Society" in Gregory, S. P, (editor) *The Scientific American Book of Dinosaurs,* St. Martin's press, New York, 424pp.

Malkani, M. S. (2003a). Discovery of Partial Skull and Dentary of Titanosauria (Sauropod dinosaur) from the Late Cretaceous Pab Formation of Vitakri area, Barkhan district, Balochistan, Pakistan. *Geol. Bull.Uni. Peshawar* (**36**): 65-71.

Malkani, M. S. (2003b) Pakistani Titanosauria; are armoured dinosaurs?. *Geological Bulletin University of Peshawar* (**36**): 85-91.

Malkani, M. S. (2003c) First Jurassic dinosaur fossils found from Kirthar range, Khuzdar District, Balochistan, Pakistan. *Geological Bulletin University of Peshawar* (**36**): 73-83.

Malkani, M. S. (2004a) Saurischian dinosaurs from Late Cretaceous of Pakistan. In: Abstract volume of *Fifth Pakistan Geological Congress* (Hussain, S.S., and Akbar, H. D., eds.), National Geological Society of Pakistan, Pakistan Museum of Natural History, Islamabad, 71-73.

Malkani, M. S. (2004b) First diagnostic fossils of Late Cretaceous Crocodyliform (Mesueucrocoreptilia) from Pakistan. In: Abstract volume of *Fifth Pakistan Geological Congress* (Hussain, S.S., and Akbar, H. D., eds.), National Geological Society of Pakistan, Pakistan Museum of Natural History, Islamabad, 68-70.

Malkani, M. S. (2004c) Stratigraphy and Economic potential of Sulaiman, Kirthar and Makran-Siahan Ranges, Pakistan. In Hussain, S. S., and Akbar, H. D., eds., Fifth Pakistan Geological Congress, 14-15 April, Islamabad, Abstracts volume, National Geol. Soc. Pak., Pakistan Museum of Natural History (Pakistan Science Foundation), Islamabad. 63-66.

Malkani, M. S. (2006a) Diversity of Saurischian dinosaurs from Pakistan. In: Ist *International Conference on Biotechnology and Informatics, 10th -12th April,2006, Quetta, Pakistan*, Additional abstracts volume, Faculty of Biotechnology and Informatics, Balochistan University of Information Technology and Management Sciences, Quetta, Pakistan, 103Pp.

Malkani, M. S. (2006b) Biodiversity of saurischian dinosaurs from the latest Cretaceous Park of Pakistan. *Journal of Applied and Emerging Sciences*, 1 (**3**): 108-140.

Malkani, M. S. (2006c) Cervicodorsal, Dorsal and Sacral vertebrae of Titanosauria (Sauropod Dinosaurs) discovered from the Latest Cretaceous Dinosaur beds/Vitakri Member of Pab Formation, Sulaiman Foldbelt, Pakistan. *Journal of Applied and Emerging Sciences*, 1 (**3**): 188-196.

Malkani, M. S. (2006d) Lithofacies and Lateral extension of Latest Cretaceous Dinosaur beds from Sulaiman foldbelt, Pakistan. *Sindh University Research Journal (Science Series)* 38 (**1**): 1-32.

Malkani, M. S. (2006e) First Rostrum of Carnivorous *Vitakridrinda* (Abelisaurids Theropod dinosaur) found from the Latest Cretaceous Dinosaur beds (Vitakri) Member of Pab Formation, Alam Kali Kakor Locality of Vitakri area, Barkhan District, Balochistan, Pakistan. *Sindh University Research Journal (Science Series)* 38 (**2**): 5-24.

Malkani, M. S. (2007a) Trackways evidence of sauropod dinosaurs confronted by a theropod found from Middle Jurassic Samana Suk Limestone of Pakistan. *Sindh University Research Journal (Science Series)* 39 (**1**): 1-14.

Malkani, M. S. (2007b) Cretaceous Geology and dinosaurs from terrestrial strata of Pakistan. In: Lee, Y.I., Paik, I.S., Cheong. D.K., Huh, M., Lee, Y.U. (eds.), Paleoclimates in Asia during the Cretaceous: theirvariations, causes, and biotic and environmental responses. *Proceedings of the 2nd International Symposium of the IGCP Project No. 507*, August, 20-21, 2007, Seoul, Korea, 57-63.

Malkani, M.S., (2007c) Lateral and vertical rapid variable Cretaceous depositional environments and Terrestrial dinosaurs from Pakistan. In; Huang, Y., Wang, P., Gu, J., and Jing, S. eds. Abstracts volume, *Joint Workshop on Rapid Environmental/Climate Change in Cretaceous Greenhouse World: Ocean-Land Interaction and Deep Terrestrial Scientific Drilling Project of the Cretaceous Songliao Basin*, August 28-30, 2007, Daqing, China, Cretaceous World-Publication 44-47.

Malkani, M.S., (2007d) First diagnostic fossils of Late Cretaceous Crocodyliform (Mesoeucrocodylia, Reptilia) from Vitakri area, Barkhan District, Balochistan, Pakistan. In; Ashraf, M., Hussain, S. S., and Akbar, H. D. eds. Contribution to Geology of Pakistan 2007, *Proceedings of 5th Pakistan Geological Congress 2004, A Publication of the National Geological Society of Pakistan, Pakistan Museum of Natural History, Islamabad*, Pakistan, 241-259.

Malkani, M. S. (2007e) Paleobiogeographic implications of titanosaurian sauropod and abelisaurian theropod dinosaurs from Pakistan. *Sindh University Research Journal (Science Series)* 39 (**2**): 33-54.

Malkani, M.S. (2008a) First articulated Atlas-axis complex of Titanosauria (Sauropoda, Dinosauria) uncovered from the latest Cretaceous Vitakri member (Dinosaur beds) of upper Pab Formation, Kinwa locality of Sulaiman Basin, Pakistan. *Sindh University Research Journal (Science Series) 40* (**1**): 55-70.

Malkani, M.S. (2008b) Mesozoic terrestrial ecosystem from Pakistan. In, Sundquist, B. (Science Programme coordinator), *Abstracts of the 33rd International Geological Congress*, Oslo, 2008, Norway 1p. (Abstract: CD-ROM; HPF-14 Major events in the evolution of terrestrial biota, Abstract No. 1137099, 01 Pp.

Malkani, M.S. (2008c) Mesozoic terrestrial ecosystem from Pakistan. In: Lee, Y.I., Khand, Yo, & Ichinnorov, N. eds., Paleoclimates in Asia during the Cretaceous: their variations, causes, and biotic and environmental responses. *Proceedings of the 3rd International Symposium of the IGCP Project No. 507*, August, 16-17, Ulaanbaatar, Mongolia, 51-55.

Malkani, M.S. (2008d) Titanosaur (Dinosauria, Sauropoda) osteoderms from Pakistan. In: Lee, Y.I., Khand, Yo, and Ichinnorov, N. eds., Paleoclimates in Asia during the Cretaceous: their variations, causes, and biotic and environmental responses. *Proceedings of the 3rd International Symposium of the IGCP Project No. 507*, August, 16-17, Ulaanbaatar, Mongolia, 56-60.

Malkani, M. S. (2008e) Mesozoic Continental Vertebrate Community from Pakistan-An overview. *Journal of Vertebrate Paleontology* Vol. 28, Supplement to Number (**3**): 111A.

Malkani, M. S. (2008f) *Marisaurus* (Balochisauridae, Titanosauria) remains from the latest Cretaceous of Pakistan. *Sindh University Research Journal (Science Series)*, 40 (**2**): 55-78.

Malkani, M. S. (2000) in process. New *Pakisaurus* (Pakisauridae, Titanosauria, Sauropoda) remains and Cretaceous Tertiary (K/T) boundary from Pakistan.

Malkani, M. S. (2000) in process. Coal, celestite, iron and gypsum deposits found from Sulaiman basin of Pakistan.

Malkani, M.S. and C.M. Anwar. (2000) Discovery of first dinosaur fossil in Pakistan, Barkhan District, Balochistan. *Geological Survey of Pakistan Information Release*, (**732**): 1-16.

Malkani, M.S., J.A. Wilson and P.D. Gingerich. (2001) First Dinosaurs from Pakistan. *Journal of Vertebrate Paleontology* Vol. (21): Supplement to No. (**3**): 77Pp.

McIntosh, J.S. (1990) Sauropoda. In: Weishampel D.B. Dodson P. Osmolska H. eds. The Dinosauria, Berkely, University of California Press, 345-401.

Marsh, O.C. (1878) Principal Characters of American Jurassic dinosaurs. *Part I. Am. Jour. Sci.* (**16**): 411-416.

Marsh, O.C. (1881) Classification of the Dinosauria. *American Journal of Science Series* 3 (**23**): 81-86.

Marsh, O.C. (1884) Principal characters of american Jurassic dinosaurs. Part 8. The Order Theropoda. American Journal of Science Series 3 (**27**): 329-341.

Molnar, R.E. (1991) The cranial morphology of *Tyranosaurus rex*. *Paleontographica*, A, (**217**): 137-176.

Molnar, R.E. and J.O. Farlow. (1990) Carnosaur paleobiology, in Weishampel D. B., P. Dodson and H. Osmolska. (Eds.), *The Dinosauria*, Univ. California Press, Berkeley, 210-224.

Norell, M.A., J.M. Clark, L.M. Chiappe and D. Dashzeveg. (1995) A nesting dinosaur. *Nature* (**378**): 774-776.

Ostrom, J.H. (1969) Osteology of Deinonychus antirrhopus, an unusual theropod from the Lower Cretaceous of Montana. *Bulletin of the Peabody museum of natural history* (30): 1-165.

Owen, R., (1842) Report on British fossil reptiles, Pt. II. Reptiles. *Report of the British Association for the Advancement of Science,* (**1841**) 60-204.

Powell, J.E. (2003) Revision of South American titanosaurid dinosaurs: paleobiological, paleobiogeographical and phylogenetic aspects. *Records of the Queen Victoria Museum* (**111**): 01-94.

Roach, B.T. and D.L. Brinkman. (2007) A reevaluation of cooperative pack hunting and gregariousness in *Deinonychus antirrhopus* and other nonavian theropods. *Bull. of the Peabody Mus. Nat. Hist*.48 (**1**): 103-138.

Rothschild, B.M. and D.H. Tanke, (1992) Paleopathology of Vertebrates: Insights to lifestyle and health in the geological record. *Geosci. Can.* 19 (**2**): 73-82.

Salgado, L, R.A. Coria and J.O. Calvo (1997) Evolution of titanosaurid sauropods. I1; Phylogenitic analysis based on the cranial evidence. *Ameghiniana* (34): 33-48.

Seeley, H.G., (1888) The classification of the Dinosauria. *British Association for the advancement of Science, Report,* (**1887**): 698-699.

Tanke, D.H., and P.J. Currie (1998) Head biting behavior in theropod dinosaurs: paleopathological evidence. *Gaia* (**15**): 167-184.

Thulborn, T. (1989) The gaits of dinosaurs, in Gilletted, D. and Lockley, M.G. (eds.), *Dinosaur tracks and traces.* Cambridge Univ. Press, Cambridge, 39-50.

Wilson, J.A, M.S. Malkani and P.D. Gingerich. (2001) New Crocodyliform (Reptilia, Mesoeucrocodylia) form the upper Cretaceous Pab Formation of Vitakri, Balochistan (Pakistan), *Contributions form the Museum of Paleontology, The University of Michigan,* 30 (**12**): 321-336.

Wilson, J.A, M.S. Malkani and P.D. Gingerich. (2005) A sauropod braincase from the Pab Formation (Upper Cretaceous, Maast.) of Balochistan, Pakistan. *Gondwana Geological Magazine*, Special Vol. (**8**): 101-109.

Wilson, J.A. (2006) An overview of titanosaur evolution and phylogeny. En (Colectivo Arqueologico-Paleontologico Salense, Ed.), *Actas de las III Jornadas sobre Dinosaurios y su Entorno* 169-190.