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Devonian vertebrate biostratigraphy of central Iran

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Abstract – Middle to Late Devonian fish faunas are known from different parts of central Iran. These faunas comprise thelodonts, acanthodians, actinopterygians, chondrichthyans, sarcopterygians, thelodonts and placoderms which are predominantly found in marine deposits. This study surveys previous and current work done on the biostratigraphy of micro and macro vertebrates from ten localities. These localities are: Soh limestone beds, north of Esfahan (*hemiansatus* to Early and Middle *varcus* Zones); Ab-e-Morad, Chanaruh (Bidou), Hutk and Tangile-ab-Garm (Ravar) localities in Kerman Province (Early *varcus* Zone to Early Frasnian); Chahriseh area of northeastern Esfahan (probably Late Givetian or Early Frasnian, *jamieae, crepida* to *rhomboidea* and *postera* to *expansa* Zones); Howz-e-Dorah and Niaz sections at the Shotori Range, Tabas region (*falsiovalis, linguiformis, crepida, expansa* to Middle *praesulcata* Zones); and the Garigoon Mountains in the Dalmeh area, northeastern Ardekan (*triangularis* to *crepida* and *postera* to Early *expansa* Zones). Faunal assemblages with their age constraints from these localities are described throughout the Bahram, Shishtu and other equivalent Formations.

INTRODUCTION

Rieben (1935) first recorded Devonian vertebrates from northwestern Iran (Zonus area, Azerbaijan), but the first report on Devonian vertebrates made in central Iran (Kerman) was by Huckriede *et al.* (1962), near thirty years later. The fish palaeontology was first studied by Golshani *et al.* (1972) and continued with many joint French – Iranian projects (e.g. Blieck and Goujet 1978; Janvier and Martin 1978, 1979; Lelievre *et al.* 1981). In recent years other workers have collected and studied Middle to Late Devonian fish materials from various localities (Figure 1), especially the Late Devonian successions of central, western and eastern central Iran (e.g. Hairapetian and Gholamalian 1998; Long and Adhamian 2000; Long and Hairapetian 2000; Yazdi and Turner 2000). These studies have provided new data on micro and macrovertebrates from central Iran with well constrained ages, useful for international correlation, based on fishes, specially in former Gondwana lands (Figure 2). Here, we provide a summary of micro and macrovertebrate faunas with their ages in order to increase our knowledge of Devonian vertebrates from northern Gondwana (Figure 3). Unpublished reports have not been included in this survey. The Late Devonian zonal scheme of Ziegler and Sandberg (1984, 1990) and the Devonian correlation chart of Weddige (1996) are used herein.

THE VERTEBRATE FAUNAS

1. Kerman fauna

One of the most important vertebrate faunas in the Middle East comes from the southeastern part of central Iran, named by Lelievre *et al.* (1993), as the Kerman fauna. They gave a summary of the fauna of Tangile – ab – Garm, Hutk, Ab – e – Morad and Chanbaruh (Bidou) localities (Figure 1). The component taxa of these areas seems to be as a mixture of Baltican and Gondwanan forms, with a larger number of widespread taxa (Lelievre *et al.* 1993). Lelievre *et al.* (1993) gives the faunal list from these localities as:

Thelodonti:

Turinia hutkensis Blieck and Goujet 1978

Acanthodi:

Persacanthus kermanensis Janvier 1977

? Climatiida gen. et sp. indet.

?Acanthodida gen. et sp. indet.

Placodermi:

Golshanichthys asiatica Lelievre, Janvier and Goujet 1981

Holonema cf. *H. radiatum* Obruchev 1933

Eastmanosteus sp.

Plourdosteus sp.

Asterolepis sp.

? *Byssacanthus* sp.

? *Aspidichthys* sp.

Figure 1 Map of Iran showing major localities for Devonian vertebrates.

Ptyctodontida aff. *Ptyctodus* sp.
Ptyctodontida aff. *Rhynchodus* sp.
? Petalichthyida gen. et sp. indet.
Dinichthidae gen. et sp. indet.

Chondrichthyes:
Ctenacanthus sp.
'Cladodus' sp.
Protacrodus sp.

Actinopterygii:
Moythmasia sp.

Sarcopterygii:
Onychodontiformes
Onychodus firouzi Janvier and Martin 1978
Strunius rolandi Gross 1956
Osteolepiformes
Osteolepididae gen. et sp. indet.

Dipnoi:
Iranorhynchus seyedemanii Janvier and Martin 1978
Rhinodipterus sp.
? *Dipterus* sp.
? *Chirodipterus* sp.
? Rhynchodipteridae gen. et sp. indet.

Age constraints

Conodonts provide some age control on the Kerman fauna. According to the conodonts recovered by Huckriede *et al.* (1962), Kerman localities have age ranges from Late Givetian to Early Frasnian. Dastanpour (1990, 1996) examined some of the mentioned sections and additional ones on the basis of brachiopods and palynomorphs which he distinguished as Late Devonian (Frasnian). Useful fish elements for marine/

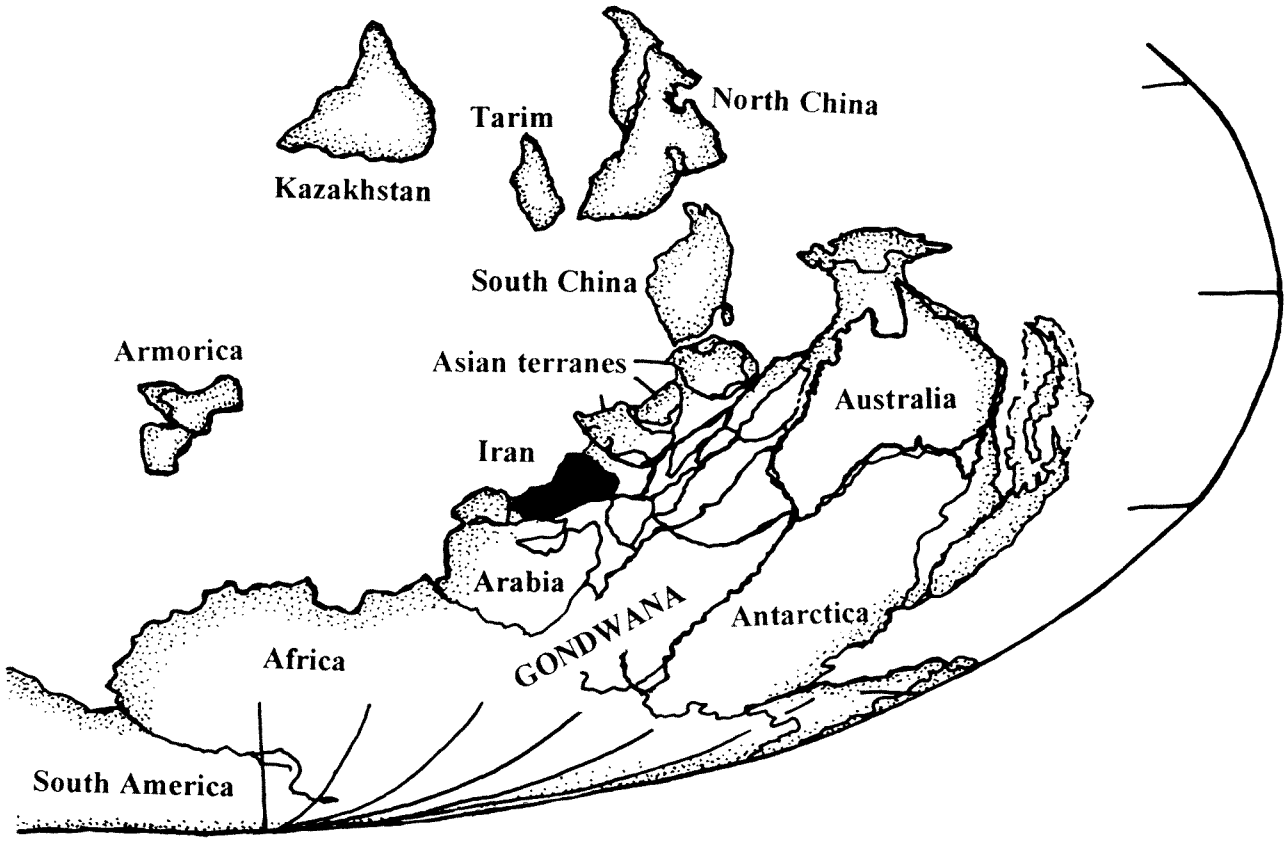

Figure 2 Palaeogeographic reconstruction for the Late Devonian (Famennian), showing the position of the Iran block (in black) with respect to the northern margin of Gondwana. After Li *et al.* (1993).

nonmarine correlation in Gondwanan lands are thelodont scales from Latest Silurian to early Late Devonian (Turner 1997). Blieck and Goujet (1978) suggested a late Early Devonian to Middle Devonian age for the thelodont *Turinia hutkensis* from limestone beds in Hutk section (part of the Bahram Formation). The lowermost limestone layer is attributed to the Givetian (Lower *varcus/disparilis* Zone) in Hutk area, based on conodonts (Wendt *et al.* 1997).

2. Soh fauna

The Middle Devonian (Givetian) successions in western central Iran are well exposed in the Soh area, northern Esfahan (Figure 1). This new locality has been yielded thelodonts, acanthodians and palaeoniscoids in a few limestone beds (Long and Adhamian 2000).

The identified microvertebrates from this area are as follows:

Thelodonti:
Turinia sp.

Acanthodi:
Cheiracanthoides cf. *C. comptus* Wells 1944

Actinopterygii:
Palaeoniscoidae gen. et sp. indet.

Age constraints

The upper Middle Devonian sediments of Soh was studied by Zahedi (1973), but further investigation in 1999 by Adhamian provided reliable age attributions. The age of the Soh fish bearing beds can be considered as Givetian stage, according to Adhamian (1999). The recovered shallow water conodonts from Soh section here indicate *hemiansatus* to early and middle *varcus* Zones (Adhamian 1999).

3. Chahriseh fauna

Palaeontological studies in the Chahriseh area were not reported on macro and micro vertebrates until 1998. Previous workers measured sections and mapped the area several times (e.g. Djafarian and Brice 1973; Shirani 1995 and Hamedani 1996). The probably Late Givetian, Frasnian and Famennian fish-bearing beds in this section are rich in thelodonts, placoderms, sarcopterygians, acanthodians and few shark microremains which were reported and studied by Hairapetian and Gholamalian (1998), and by Long and Harapetian (in press). Also recently, Golamalian *et al.* (2000), reported a considerable number of thelodont and acanthodian microremains. Based on these studies, the faunal list is as follows:

Thelodonti:
Turinia hutkensis Blieck and Goujet 1978
Australolepis seddoni Turner and Dring 1981

Acanthodi:
cf. *Nostolepis gaujensis* Valiukevicius 1998

Placodermi:
Bothriolepis sp.
Ptyctodontidae gen. et sp. indet.
Arthrodira gen. et sp. Indet.

Actinopterygii:
Moythomasia durgaringa Gardiner and Bartram 1977

Chondrichthyes:
Thrinacodus ferox (Turner 1982)
Phoebodus sp. (Hairapetian pers. obs.)
Protacrodus sp.
Stethacanthus sp.
"Cladodus" sp.

Dipnoi:
Adololopas sp. Campbell and Barwick 1998
Chirodipterus sp. aff. *C. australis* Miles 1977
Dipteridae gen. et. sp. Indeterminate.

Crossopterygii:
Onychodus sp.
Osteolepididae gen. et sp. indet.

Age constraints

The age of the thelodont assemblage from a calcareous sandstone bed can be attributed to Early Frasnian on the basis of conodonts and palynomorphs. But the presence of one incomplete doubtful element of the genus *Bippenathus* suggests an older age than Early Frasnian time for this horizon (Gholamalian *et al.* 2000). The presence of *Australolepis seddoni* associated with *Turinia hutkensis* is a most remarkable feature of. These new data on the stratigraphical position of *T. hutkensis* can be used as a thelodont zone for world-wide biostratigraphic correlation in the Early Frasnian (Gholamalian *et al.* 2000). The large and well-preserved placoderm, crossopterygian and dipoan remains were found and studied by Long and Hairapetian (in prep). These all come from thin bedded fossiliferous limestone which can be considered a Middle Frasnian age (*jamieae* Zone), based on conodonts (Hairapetian and Gholamalian 1998). A microvertebrate fauna of Early and Middle Famennian age occurs in the upper part of the Chahriseh section, but has not yielded many specimens of fish microremains.

4. Tabas (Shotori Range) fauna

The Shotori Range in Tabas vicinity (eastern central Iran) comprises two main sections in Late Devonian age (Howz-e-Dorah and Niaz sections). These have been measured and studied, and dated by conodont biostratigraphy (M. Yazdi, pers. comm. 1999). The well-exposed Late Devonian sections in both localities have been yielded Frasnian and Famennian vertebrates, throughout the Bahram and Shistu Formations (e.g. Schultze 1973; Yazdi and Turner 2000). The fauna is:

Thelodonti:
Australolepis seddoni Turner and Dring 1981

Placodermi:
Aspidichthys cf. *ingens* Koenen 1883
Holonema cf. *H. rugosum* Claypole 1883
Eastmanosteus sp.
Dunkleosteus sp.

Acanthodi:
'Acanthodes' sp.
Chondrichthyes:
Phoebodus rayi Ginter and Turner 1999
Protacrodus sp.
Symmoriida gen. et sp. indet.
? *Stethacanthus* sp.
? *"Cladodus"* sp.

Sarcopterygii:
? *Onychodus* sp.

Age constraints

The thelodont *Australolepis seddoni* confirms an Early Frasnian age (*falsiovalis* Zone) in the base of the Bahram Formation (e.g. Turner 2000). Large Late Devonian arthrodires are abundant in the Tabas fauna which can be considered as a key bed in the *linguiformis* Zone, below the F/F boundary.

The phoebodont teeth occur with many conodont species/subspecies in the Shotori Range samples are of confirmed *crepdia* Zone (Early Famannian) through the Shishtu Formation (e.g. Yazdi and Turner 2000). A small microvertebrate fauna from Howz-e-Dorah samples in the age of *expansa* – Middle *praesulcata* Zone (Late Famennian) has been recognised by Yazdi (pers. comm.).

5. Dalmeh Fauna

The present of Famennian vertebrates is documented in northeastern Ardekan, Garigoon Mountains by Long and Hairapetian (2000). This section is slightly metamorphosed, but has yielded many well-preserved microvertebrates. The new locality is extremely rich in shark and palaeoniscoid remains. Based on Long and Hairapetian (2000), the faunal content is as follows:

Chondrichthyes:
Thrinacodus ferox (Turner 1982)
Phoebodus gothicus Ginter 1990
Stethacanthus sp.

Fauna	Occurrence (central Iran)	Stage	Dating	Formation
Dalmeh	central	Famennian	E.*expansa-postera*	Shishtu equivalent
			crepida-triangularis	
Shotori Range	eastern	Famennian	M.*praesulcata-expansa*	Shishtu
			crepida	
		Frasnian	*linguiformis*	
			E. *falisovalis*	Bahram
Chariseh	western	Famennian	*postera-expansa*	Shishtu equivalent
			rhomboidea-crepida	
		Frasnian	*jamieae*	
		Frasnian-?Givetian	*falisovalis*-?Late Givetian	Bahram equivalent
Kerman (Hukt, Tangil-e-ab-Garm, Ab-e-Morad, Chanaruh)	south-eastern	Frasnian	Early Frasnian	Bahram
		Givetian	*disparilis*-E. *varcus*	
Soh	western	Givetian	M. *varcus*-*hemiansatus*	Bahram equivalent

Figure 3 Chart showing the distribution of Middle-Late Devonian vertebrate faunas of central Iran.

Dalmehodus turnerae Long and Hairpetian 2000
Protacrodus sp.
Orodontidae gen. et sp. indet.

Actinopterygii:
Moythmasia durgaringa
Palaeoniscoidae gen. et. sp. indet.

A minor locality has also been found in Anjireh, near Yazd (Figure 1) which yielded Frasnian fish beds (e.g. Janvier 1980; Lelievre *et al.* 1993), but faunal content is unknown to the authors.

Age constraints

Hairapetian (2000) studied a section in northwestern Dalmeh area in which, on the basis of conodonts, a carbonate section was dated from Late Frasnian to Late Famennian. Famennian successions in the Dalmeh area have yielded many fish horizons associated with submarine basic volcanic rocks. The most important fish-bearing beds belong to *triangular's* – *crepida* and *postera* – Early *expansa* Zones, but very few vertebrate remains occur in the Middle Famennian.

Concluding Remarks

Many of the faunas are currently still being studied, and only provisional results are summarised herein. Devonian vertebrate studies of central Iran are providing new knowledge on the evolutionary, biogeographic and biostratigraphic patterns of former Gondwanan terranes. From this review, it is clear that most of the Givetian to Early

Frasnian successions in central Iran (except the Dalmeh section) have yielded thelodont taxa. The thelodont scales are recognised as an important taxa for biostratigraphy (Turner 1997) that can be used for correlation of Middle and early Late Devonian marine/nonmarine sections in most of Central Iran. The phoebodont–based zonation chart of Ginter and Ivanov (1995) is useful for biostratigraphy in the Late Devonian (especially Famennian) of central Iran. Finally, the macrovertebrate faunas will also prove to be valuable for biostratigraphy once detailed studies of them have been completed.

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