

REVISION OF THE GENUS *HUNDWARELLA* REED AND ITS SIGNIFICANCE IN HIMALAYAN CAMBRIAN

S.K. SHAH, C.S. SUDAN, S.K. PARCHA AND ALOK K. RAINA
 DEPARTMENT OF GEOLOGY, UNIVERSITY OF JAMMU, JAMMU - 180001.

ABSTRACT

The trilobite genus *Hundwarella* Reed constitutes an important element of the Middle and early Late Cambrian sequence of the Asiatic province and is widely distributed in the Himalayan succession. The early Middle Cambrian species viz., *Hundwarella personata*, *H. transversa* and *H. convexa* show a transglabellar bigenulate third furrow which encloses a triangular tract. This furrow becomes gradually effaced in such late Middle Cambrian forms as *Hundwarella kingi* and this trend continues in early Late Cambrian forms like *Hundwarella rushtoni*. Modification of the preglabellar area is also prominent. The various species referred to this genus from time to time have been revised and reassigned and four new species viz., *Hundwarella transversa*, *H. convexa*, *H. kingi* and *H. rushtoni* described. The generic diagnosis has been revised in the light of these new species.

INTRODUCTION

The various species of the genus *Hundwarella* are known in all the fossiliferous Middle and early Late Cambrian sequences in Himalaya and many parts of Asia. This genus is one of the important provincial elements of the Middle and Late Cambrian which is not known outside the Asiatic region. Its various species exhibit a linear evolutionary pattern and, therefore, clearly have stratigraphic significance. On the basis of earlier descriptions and the discovery of new species from the Cambrian of Kashmir and Spiti, the genus is now revised. The study of various species at different stratigraphic levels indicate a pattern of evolution and migration in different Cambrian basins.

The fossiliferous Middle and early Late Cambrian in Himalaya is known from the Tethys succession in Kashmir and Spiti only, since in Lesser Himalaya only the Lower Cambrian is reported so far. The stratigraphic succession of these two regions is given in the Fig.1.

Both in the Cambrian of Spiti and that of Kashmir the fossils are obtained from argillaceous rocks which are folded. As a result the tectonic deformation has brought about some distortion in fossils. By and large the distortion is unidirectional resulting in elongation or shortening of the exoskeletons or deshaping of the fossils. However, this distortion does not affect, to any appreciable extent, the deepening or weakening of the glabellar furrows.

TAXONOMIC STATUS OF HUNDWARELLA

The genus *Hundwarella* was erected by Reed (1934) with *Hundwarella personata* as genotype. The subsequently described genus *Irania* King which was revised to *Iranoleesia* King (1955) was based on the

bifurcation of posterior pair of glabellar furrow and its effacement mesially. A similar bifurcation is also seen in *Hundwarella*, as is indicated in various other species described herein. In stratigraphic sequence the posterior glabellar furrow, which is initially fully transglabellar, becomes effaced mesially. Accordingly, the genus *Iranoleesia* is considered to be a synonym of *Hundwarella* (Shah & Raina, in press). The two show a minor variation in palpebral lobes, but all other characters are identical.

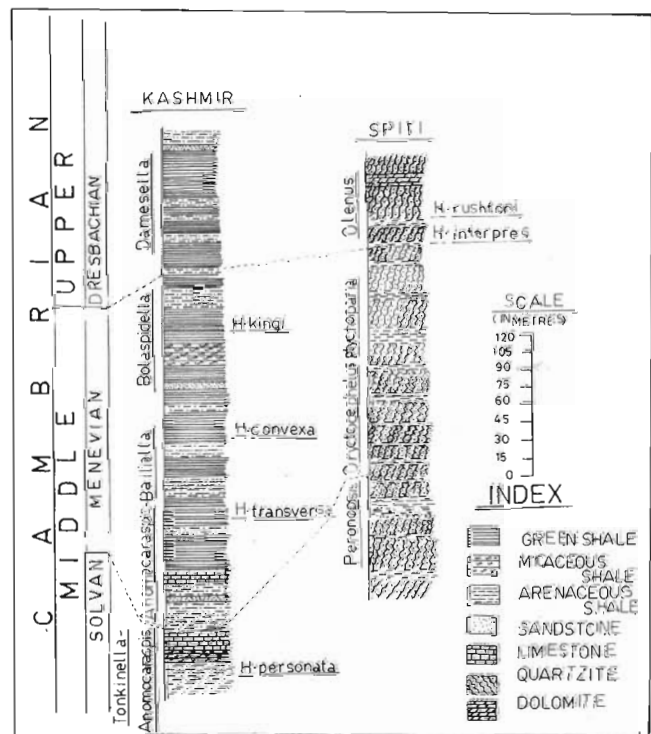


Fig. 1. Lithostratigraphic columns of Kashmir and Spiti sharing the occurrence of *Hundwarella* at different stratigraphic levels.

The list of various species which have been referred to the genus *Hundwarella* from time to time by different workers is given below:-

- Hundwarella personata* Reed, 1934 (Genotype)
H. remota Reed, 1934
H. minus (Dames) Kobayashi, 1944
H. termieri (Mansuy) Kobayashi, 1944
H. tienfongensis (Mansuy) Kobayashi, 1944
Iranoleesia pisiformis King, 1955
I. falconi King, 1955
Hundwarella (*Honanaspis*) *matsuhitai* Kobayashi, 1962
H. (*Honanaspis*) *honanensis* Kobayashi, 1962
H. haimantensis (Reed) Kobayashi, 1967

The revised list of the species being referred to the genus *Hundwarella* on the basis of the present studies is indicated below with their original names:-

Original names	Revised names
<i>Prosaugia middlemissi</i> Reed, 1934	<i>Hundwarella personata</i> (Reed)
<i>Iranoleesia pisiformis</i> King, 1955	<i>H. pisiformis</i> (King)
<i>I. falconi</i> King, 1955	<i>H. falconi</i> (King)
<i>Conokephalina tienfongensis</i> Mansuy, 1916	<i>H. tienfongensis</i> (Mansuy)
<i>C. termieri</i> Mansuy, 1916	<i>H. termieri</i> (Mansuy)
<i>Bathyriscus ?stoliczkai</i> Reed, 1910	<i>H. interpres</i> (Reed)
<i>Dikelocephalus ?interpres</i> Reed, 1910	<i>H. interpres</i> (Reed)
<i>Iranoleesia orlovi</i> Gupta & Suneja, 1977	<i>H. orlovi</i> (Gupta & Suneja)
<i>I. kobayashii</i> Gupta & Suneja, 1977	<i>H. kobayashii</i> (Gupta & Suneja)
<i>I. pandei</i> Gupta & Suneja, 1977	<i>H. pandei</i> (Gupta & Suneja)
<i>I. rasettii</i> Gupta & Suneja, 1977	<i>H. rasettii</i> (Gupta & Suneja)

The following cannot be included in *Hundwarella* and their revised position is indicated:-

Original	Revised
<i>Hundwarella remota</i> Reed, 1934	<i>Tonkinella</i>
<i>Hundwarella</i> (<i>Honanaspis</i>) <i>matsuhitai</i> Kobayashi, 1962	<i>Proasphiscus</i>
<i>Hundwarella</i> (<i>Honanaspis</i>) <i>honanensis</i> Kobayashi, 1962	<i>Proasphiscus</i>

- Hundwarella haimantensis* (Reed) Kobayashi, 1967
Hundwarella minus Kobayashi, 1944
Olenus haimantensis
Anomocare minus

The following new species of *Hundwarella* from Kashmir and Spiti are described here:

- Hundwarella transversa* sp. nov.
H. convexa sp. nov.
H. kingi sp. nov.
H. rushtoni sp. nov.

Hundwarella ? remota described by Reed (1934) is represented only by a large sized single pygidium which can be referred to *Tonkinella*.

Honanaspis was erected by Chang (1959) as subgenus of *Proasaphicus* with *P. (Honanaspis) honanensis* as its type species. Kobayashi (1944) considered *Hundwarella* as a subgenus of *Manchurella* Kobayashi, and later (Kobayashi, 1962) described *Honanaspis* Chang (1959) as a subgenus of *Hundwarella* and included *Proasaphicus (Honanaspis) matsuhitsi* in it. The latter is closely allied to *Anomocare minus*. These species cannot be referred to genus *Hundwarella* even at the subgeneric level since they do not possess the kind of glabellar furrows characteristic of *Hundwarella*.

Kobayashi (1962, p. 113) considered *Anomocare dimotum*, *A. novatum*, *A. suspectum* and *A. perfunctum* as congeneric with *Hundwarella personata*. But in the same publication (p. 110-112) he has placed these species doubtfully in genus *Anomocaraspis*. However, in having a more elongated cranidium, three pairs of faint or obsolete glabellar furrows of which the posterior pair is neither bifid nor forms a triangular tract, these cannot be grouped in *Hundwarella*. They can be included in genus *Anomocaraspis* with *A. hundwarensis* as type species as has been done by Ivshin (1953).

Conokephalina termieri and *C. tienfongensis* were referred to genus *Manchurella* and subgenus *Hundwarella* by Kobayashi (1944). These species can easily be grouped within *Hundwarella* on account of generic characters especially in the nature of the bifid posterior glabellar furrow and in the convex nature of the cranidia.

Kobayashi (1967) also transferred *Olenus ? haimantensis* Reed from Spiti to the genus *Hundwarella*. But *Olenus ? haimantensis* is a distinctive form in having a subtrapezoidal glabella, raised anterior border, almost straight eye ridges and a single rare lateral glabellar furrow. All these characters differentiate *Olenus haimantensis* from *Hundwarella* and this assignment does not seem to be correct.

Prosaukia middlemissi Reed (1934) is congeneric with *Hundwarella personata* due to its close affinity in the glabellar furrows, convex nature, curved occipital ring, wide preglabellar area, large eyes and in the nature of anterior border. *Iranoleesia kobayashii*, *I. pandei*, *I. rasettii* and *I. orlovi* can be easily grouped with the genus *Hundwarella* as all these possess the characters of the genus especially the bifid nature of the posterior glabellar furrow and in the convex nature of cranidia.

REPOSITORY

All the type material is housed in the Palaeontology Museum of the Department of Geology in the University of Jammu and specimens are numbered from KUF 546 to KUF 601.

SYSTEMATIC DESCRIPTION

Class	Trilobita
Order	Ptychopariida SWINNERTON, 1915
Suborder	Ptychopariina RICHTER, 1933
Superfamily	Asaphiscacea RAYMOND, 1924
Family	Asaphiscidae RAYMOND, 1924
Subfamily	Asaphiscinaea RAYMOND, 1924
Genus	<i>Hundwarella</i> REED, 1934 <i>Irania</i> KING, 1934 <i>Iranoleesia</i> KING, 1955

Generic characters: Cranium convex in outline; preglabellar area moderately short to wide; anterior border curved to slightly transverse in outline; glabella subcylindrical, number of glabellar furrows varying from three to four, posterior pair making a triangular tract and sometimes effaced in the middle; thoracic segments varying in number from eleven to thirteen, axis of thorax convex, gradually tapering posteriorly; thoracic axial furrows shallow. Pygidium comprising five segments with axis tapering posteriorly, nearly extending to the marginal furrow, pleural furrows strong.

Genotype: *Hundwarella personata* Reed, 1934

Hundwarella transversa n. sp.
(Pl. I-a,b,o,p)

Etymology: The name is based on the nearly straight anterior border which is the characteristic of the species.

Material: Ten well preserved and two deformed cranidia (Nos. KUF550 to 561). Thorax and pygidium unknown.

Diagnosis: Anterior border transverse and nearly

straight; cranial width greater than the length, anteriorly tapering and subrounded glabella; three pairs of lateral glabellar furrows, the posteriormost bifurcating and enclosing a triangular tract; the ratio of width of preglabellar area and anterior border is 1:1.

Description: Cranium subrectangular in outline with width greater than length; glabella convex, slightly raised above the cheeks, occupying nearly three quarters the length of cranium, width slightly lesser than length, tapering anteriorly, subrounded in front, maximum width towards the posterior side; three pairs of lateral glabellar furrows present, anteriormost pair short, horizontal, median pair slightly longer than anterior pair, posterior pair deep, oblique, bifid and directed backwards making an inverted equilateral triangular tract at centre; occipital furrow shallow, slightly arched backwardly, occipital ring wider in middle extending forward in the centre, a trace of an occipital node clearly visible: eye ridges sharp and start obliquely outward from the glabella near the anterior glabellar furrow, eyes crescent shaped, medium sized, situated opposite the mid length of glabella; width of the fixigenae near palpebral lobes about 0.6 that of the middle part of glabella; preglabellar area present, the ratio of preglabellar area and anterior border width nearly 1:1, anterior border nearly of uniform width, transverse in outline, facial suture cuts the anterolateral margins of the anterior border, then turns backwards and inward to reach the palpebral lobes, the posterior section of the facial suture divergent and starting obliquely outward from the rear end of the palpebral lobe to the postero-lateral extremities of the cranium.

Dimensions: (in mm.)

	KUF 550 (Holo- type)	KUF 551	KUF 552	KUF 553	KUF 554
Cranidium	7.5	7	7.3	7.4	8.5
Length of cranium					
Width of cranium at palpebral lobes	10	9.5	9.3	10	10.2
Length of glabella	6	6	5.9	5.8	6.5
Basal width of glabella	5	5	4.8	5.1	5.2
Preglabellar area (length)	0.8	0.5	0.7	0.6	0.9
Width of anterior border	0.7	0.5	+ 0.3	+ 0.2	0.8

Discussion: The species show some resemblance to *Hundwarella personata* Reed in glabellar details of cranium, but differs from it in having a narrow preglabellar area, transverse anterior border and shorter palpebral lobes.

The species differs from *Hundwarella pisiformis*

(King) in the smaller size of the eyes, transverse nature of the anterior border, shorter palpebral lobes and the presence of triangular tract constituting posteriormost pair of glabellar furrows. In *H. pisiformis* the anterior border is curved, preglabellar area is wide and posterior pair of glabellar furrow is effaced in the middle.

The specimens differ from *H. kobayashii*, *H. orlovi*, and *H. pandei*, since all these have four glabellar furrows in addition to a different furrow design and wider preglabellar area.

Horizon and locality: The specimens have been collected from *Anomocaraspis - Bailella* Zone of northwestern Kashmir.

Hundwarella convexa n. sp.
(Pl. I — c,d,e,f,g,k,n)

Etymology: The name is based on the convexity of the outline of the anterior border.

Material: Nine well preserved cranidia and two dorsal exoskeletons without pygidia (Nos. KUF 562, 563a, 563b, 564a, 564b, 565a, 565b and 566 to 569); pygidium not known.

Diagnosis: Glabella convex, moderately tapering anteriorly, subrounded in front, three pairs of lateral glabellar furrows prominent, of which the posterior pair are directed backwards making an inverted equilateral triangular tract at centre; occipital furrow shallow, arched backwardly; occipital ring slightly wider at middle; eyes of medium size, situated opposite the median length of glabella; eye ridges prominent; ratio of preglabellar field and anterior border nearly of uniform width, convex outline; axis of thorax convex, tapering gradually backwards, number of axial rings eleven; thoracic axial furrows shallow.

Description: Cranidium subquadrate with width greater than length; glabella convex slightly raised above the cheeks, occupying nearly three-fourth the length of the cranidium, width lesser than length, tapering anteriorly, subrounded in front; axial furrows shallow, three pairs of lateral glabellar furrows present, anteriormost and median pair short, posteriormost pair bifurcated into two, extending obliquely downwards and horizontally from the upper part forming a band; occipital ring wider in middle curving backwards at the sides; eye ridges prominent, starting obliquely outwards from the base of the anteriormost pair; eyes small, medium sized, situated opposite to the centre of the glabella; palpebral area of the fixigenae wide, greater in width than the middle width of glabella; preglabellar area present, the ratio of pre-

glabellar area and anterior border 1.5:1; anterior border convex in outline, nearly uniform in width; facial suture directed outward obliquely from eye lobes to the anterolateral margins of the anterior border and diverging obliquely outward from the rear end of the eye lobe to reach the posterolateral extremities of cranidium.

Thorax of ten to twelve segments; axis convex, gradually tapering backwards; axial rings with faint lateral swellings, axial rings ten in number; axial rings separated from one another by shallow transverse furrow; pleurae horizontal upto fulcrum, beyond which they are gently curved back to end in short pointed subfulcated extremities; surface of cranidium and thorax smooth.

Dimensions: (in mm.)

	KUF 562 (Holo- type)	KUF 563a	KUF 564a	KUF 565a	KUF 566
Cranidium					
Length of cranidium	7.5	8	8	6.5	6.4
Width of cranidium at palpebral lobes	10	10.5	10.2	8	7.6
Length of glabella	6	6.5	6.7	5.6	5.2
Basal width of glabella	5.5	5.6	5.5	4.6	4.3
Preglabellar area (length)	0.9	0.9	0.8	0.6	0.6
Width of anterior border at centre	0.6	0.6	0.7	0.4	0.4

Discussion: The species differs from *Hundwarella personata* Reed in possessing a shorter preglabellar area, smaller eye lobes, wider occipital ring in middle and curved and convex anterior border. Besides this the palpebral lobes are also narrower and shorter and eye ridges are oblique. The ratio of preglabellar area to anterior border in *H. personata* is 2:1 whereas it is 1.5:1 in *H. convexa*.

H. pisiformis and *H. falconi* (King) differ from this species in possessing weak lateral glabellar furrows, conical glabella; curved anterior border, faint eye ridges, straight occipital furrow and in well preserved occipital node.

H. convexa differs from *H. transversa* because in the former the anterior border is convex and the ratio of preglabellar area and anterior border is 1.5:1, while in the latter the anterior border is transverse and the ratio of preglabellar area and anterior border is 1:1.

H. convexa differs from *H. kobayashii*, *H. pandei* and *H. orlovi* in the absence of the fourth pair of lateral glabellar furrows.

Horizon and locality: The specimens have been collected from the *Anomocaraspis-Bailella* Zone in Kashmir.

Hundwarella kingi n-sp.
(Pl. I — h,i)

Etymology: The species is named in honour of W.B.R. King for his contribution to Cambrian trilobite taxonomy. The species would fit in his description of *Iranoleesia* which is presently considered as a synonym of *Hundwarella*.

Material: Two well preserved and two partially preserved cranidia (Nos. KUF 546 to 549). Thorax and pygidium unknown.

Diagnosis: Glabella moderately convex, with slightly tapering anterior end, front nearly straight, anterolateral ends subrounded, anterior glabellar furrow short, oblique and directed anteriorly, median pair deep, horizontal and slightly longer than the anterior pair, posterior pair well marked, bifurcating, with the posterior branches directed backwards.

Description: Cranidium subquadrate in outline, length less than the width; glabella convex moderately tapering anteriorly with its front nearly straight and subrounded at anterolateral ends; length of glabella is more or less equal to its width; three pairs of lateral glabellar furrows present; anteriormost pair short, oblique and anteriorly directed, median pair deep, horizontal and slightly longer than anterior pair, posterior pair horizontal, bifurcated with posterior branch generally oblique and directed backwards; axial furrows deep, narrow; occipital furrow shallow and moderately arched; eye ridges prominent, start obliquely outward from the base of the anterior pair of glabella, eyes medium sized, situated opposite the mid length of glabella, fixigenae sloping upwards, but not raised up to the level of glabella; palpebral area of fixigenae about 0.5 the width of glabella at middle; preglabellar area short, mildly sloping anteriorly, anterior border raised; narrow, transverse and nearly of uniform width; facial suture cut slightly inward towards palpebral lobes, curve around this lobe and finally extend backward to reach the posterolateral extremities of the cranidium, surface of the cranidium smooth.

Dimensions: (in mm.)

Cranidium	KUF 546 (Holo- type)	KUF 547	KUF 548	KUF 549
Total cranial length	10	10	10.5	10.3
Width of cranidium at palpebral lobes	12	10.5	11.8	11
Length of glabella	7.5	8	7	7.9
Width of glabella at base	7	7	6.9	7
Preglabellar area (length)	1.2	1	1.3	1
Width of anterior border	1.3	1	1.2	1

Discussion: The species shows some affinities with *Hundwarella transversa* particularly in the transverse nature of the anterior border but differs from it in the depressed preglabellar area and effaced posterior pair of glabellar furrows.

It differs from all known species of *Hundwarella* in one or other morphological characters. It differs from *H. orlovi*, *H. kobayashii* and *H. pandei* in having only three pairs of lateral glabellar furrows instead of four. It also differs in length/basal width ratio of glabella which is nearly equal in this species.

Though *H. rasettii* also has three pairs of lateral glabellar furrows, the pattern of furrows in *H. kingi* is different. In *H. kingi* anterior pair and the median pair of glabellar furrows are nearly horizontal, while the posterior pair which is bifid is directed backwards. In *H. rasettii* the median pair of glabellar furrows is directed anteriorly and the posterior pair is oblique and directed backwards.

H. pisiformis (King) also differs from *H. kingi* in its wide preglabellar area and in the forwardly arched anterior border.

H. kingi differs from *H. convexa*, *H. transversa* and *H. persnata* in the median obliteration of posterior pair of glabellar furrows.

Horizon and locality: The specimens have been collected from Khanpura section in *Bolaspiddella* Zone of northwestern Kashmir.

Hundwarella interpres (Reed)
(Pl. I — j, q, r, s, v)

Bathyriscus? *stoliczkai* Reed, 1910; Pl.5; Fig.5-8.
Dicellosephalus? *interpres* Reed, 1910; Pl.5; Fig. 9-13.

Material: One tolerably preserved complete exoskeleton, two partially broken exoskeletons and twelve cranidia in a poor state of preservation (Nos. KUF 570 to 584). The material constitutes the topotype.

Description: Exoskeleton elongate to oval, cranidium semicircular, narrow, about one and one quarter as wide as long, anterior border gently curved at the front, flattened, of uniform width, nearly as wide as preglabellar area, preglabellar area narrow, about one fifth to one sixth the length of glabella, gently convex, glabella subcylindrical to subquadrate with parallel sides, nearly three quarters the length of cranidium, weakly convex, anteriorly subrounded, the ratio between the glabellar length and its width at base is nearly 1.5:1; three pairs of lateral glabellar furrows present, of which the anterior pair is very far forward, short and straight, the median pair slightly longer, straight, posterior pair longer, bigenulate, the ante-

rior bifurcating branch short, straight, whereas the posterior branch oblique, slightly longer; fixed cheeks narrow; eye ridges distinct, oblique starting from the level of anterior pair of glabellar furrows, running posteriorly towards the eyes, eyes of medium size, eye lobes prominent, upturned, swollen, situated just opposite the posteriormost lateral glabellar furrow, occipital furrow moderately strong, gently convex, facial suture cuts anterior margins obliquely at about three times the width of glabella, arches outwards in convex curve or runs back subparallel to the eye, directed slightly inwards, posterior branches arch out in simple curve to cut posterior margins of cranidium at about 50° - 60° at about two thirds of the distances between axial furrows and genal angles; axial furrow deep, narrow, parallel, nearly as wide as the basal glabellar width; free cheeks elongate, lateral border narrow, confluent with a short, pointed gently curved genal spine, produced back to just near the third thoracic segment; posterior border narrow, short, forming pointed acute genal angles.

Thorax of 12 segments, narrow, elongate tapering gently, outer half of pleural lobes strongly arched down on each side; axis strongly convex, cylindrical, rather wide, about one-third or more the total width of thorax, axial ring simple, of uniform width, nearly straight, pleurae short, broad, flattened, straight, outer half sharply bent down and slightly back, ending in abruptly truncate pointed spines.

Pygidium parabolic to semicircular with slightly concave border, indistinctly marked off from lateral lobes, margin entire, axis conical, convex, tapering very gradually to sharply pointed extremities which reach posterior margin of pygidium, composed of five axial rings; lateral lobes composed of five complete pleurae, gently curved back, traceable nearly to margins across concave border, each with a faint median furrow.

Dimensions: (in mm)

	KUF 570	KUF 571	KUF 572	KUF 573	KUF 574	KUF 575	KUF 576
Length of complete exoskeleton	—	27	—	—	—	—	—
Total cranial length	9.2	10.5	7	11.2	7.8	8	11.2
Posterior cranial width	11.1	12.5	8	15	8	9.5	15
Total glabellar length	6.2	6.5	4.5	9	5	4.9	8.5

	KUF 570	KUF 571	KUF 572	KUF 573	KUF 574	KUF 575	KUF 576
Glabellar width at base	4.5	5	2.5	5.5	4.2	3.6	5.2
Preglabellar area	1.3	2	1	1.2	0.9	0.8	1
Anterior border	1	1.5	1.2	1.3	0.9	0.8	1.2
Width of cranidium at eye lobes	10.3	10.5	7.2	13.4	7	8	13.6
Length of thorax	—	13.5	—	—	—	—	—
Length of pygidium	—	3	—	—	—	—	—
Anterior width of pygidium	—	8	—	—	—	—	—
Length of axis of pygidium	—	1.5	—	—	—	—	—
Frontal width of pygidial axis	—	2.5	—	—	—	—	—

Discussion: In having a semicircular cranidium, narrow, gently curved anterior border, convex parallel sided glabella, three pairs of lateral glabellar furrows, of which the rear pair is bifid and lower bifurcated branch posteriorly directed, medium sized eye situated just below the glabellar mid length, oblique eye ridges, the form can be positively included in *Hundwarella*.

Bathyriscus ? *stoliczkai* and *Dikelocephalus interpres* Reed (1910) are the axially and laterally compressed forms of the same species, for which the specific name *interpres* has been retained because its description is based on better preserved specimens. However, these can neither be referred to *Bathyriscus*, nor can be assigned to *Dikelocephalus* because of the following marked differences in their characters:-

Bathyriscus differs in having a narrow glabella which is somewhat expanded anteriorly, upturned anterior border, absence of preglabellar area, larger eye lobes, thorax with nine segments, large pygidium with seven axial rings.

Dikelocephalus differs in the presence of a low glabella with nearly straight front, two pairs of faint lateral glabellar furrows, wide preglabellar area, anterior and lateral border furrow obsolete to absent, posterior border furrow narrow, long, strap like, eye ridges faint, relatively large and an elliptical pygidium.

Kobayashi (1967) has mentioned *Olenus* ? *haimantensis* Reed (1910) as congeneric with *Hundwarella*

and furthermore made *Bathyriscus* ? *stoliczkai* and *Dikelocephalus* ? *interpres* from the same stratigraphic horizon synonymous to it. *Olenus haimantensis* is a distinctive form in having a subtrapezoidal cranium, raised anterior border, oblong glabella, discontinuous single rear lateral glabellar furrow; eye ridges almost straight, nearly parallel or subparallel facial suture in front of eyes, fairly wide fixed cheeks with a long spine continuous with lateral border forming an obtuse inner spine angle, thorax with horizontal pleurae, small pygidium, triangular in shape with raised anterior border. Therefore, it neither corresponds to these specimens, nor can it be referred to *Hundwarella*.

H. personata Reed differs in having a wide preglabellar area, in the ratio of preglabellar area and anterior border which is 2:1, thick eye ridges, larger eye lobes and in the rear lateral glabellar furrow joining with another supplementary transverse furrow to enclose a central band.

H. pisiformis and *H. falconi* (King) differ from the specimens in possessing slightly wider preglabellar area, convex anterior border, glabella being of nearly equal length and width, shape of the glabella and facial suture.

H. kobayashii, *H. orlovi* and *H. pandei* described from Kashmir differ in the presence of four pairs of lateral glabellar furrows, thick eye ridges and position of eyes. *H. rasettii* differs in having a glabella of nearly equal length and width.

H. kingi differs in the shape of the cranium and glabella, straight and raised anterior border, anteriorly straight glabella having equal length and width and in having more convex and elevated fixed cheeks.

H. rushtoni n.sp. from the same horizon differs in having an anterior border which is more in width than the preglabellar area, glabella of equal length and width, anteriorly directed anterior pair of lateral glabellar furrows.

Horizon and locality: The specimens have been collected from *Olenus haimantensis* Zone in Thango section of Parahio Valley, Spiti.

Hundwarella rushtoni n.sp.
(Pl. I — l, m, t, u)

Etymology: The species is named in honour of Dr. A.W.A. Rushton in recognition of his contribution to trilobite taxonomy.

Material: One tolerably preserved complete exoskeleton and sixteen cranidia in a poor state of preservation (Nos. KUF 585 to 601).

Diagnosis: Anterior border gently curved, of uniform width, the ratio of the anterior border and preglabellar area nearly 1.7:1; glabella raised, moderately tapering anteriorly, subrounded, length of the glabella nearly same as its width, three pairs of lateral glabellar furrows, of which the anterior is small, gently directed anteriorly and the posterior one bigeniculate and bifurcating, branch posteriorly directed reaching just near the occipital ring; eyes of medium size; occipital ring gently arched posteriorly at the middle, width being slightly more at the centre than at the sides. Thorax with 12 segments. Pygidium with five axial rings.

Description: Exoskeleton oval to elongate. Cranium broadly semi-circular to subquadrate in outline, moderately convex, tapering anteriorly, anterior border narrow, weakly convex, gently curved at the front, border of uniform width, width of anterior border about 1.5 to 1.7 times more than the preglabellar area, preglabellar area very narrow, convex, tapering in front; glabella raised, convex, moderately tapering anteriorly with its front slightly rounded, giving the glabella a subrounded shape, it occupies about three quarters the total length of the cranium; glabellar length is nearly equal to its width at base; three pairs of discontinuous lateral glabellar furrows well marked, anterior pair short, less distinct slightly directed anteriorly, median pair deep, horizontal and somewhat longer than the anterior pair, posterior pair distinct, longest, horizontal, bigeniculate at the middle, the two opposite branches being effaced in the middle, of the two bifurcating branches the anterior one almost straight and short whereas the posterior is longer and oblique, directed posteriorly towards the occipital ring but stopping just above the occipital ring; fixed cheeks gently convex, upsloping but not raised up to the level of glabella, about twice the width of the glabella at base; eye ridges less distinct and starting obliquely outwards from the base of the anterior pair of glabellar furrow, eye lobes of medium size and situated below the glabellar mid length just near the third lateral glabellar furrow; palpebral mid length just near the third lateral glabellar furrow; palpebral area of fixigenae slightly less than the width of the glabella at base; facial suture with anterior branches cutting the margins of cranium about one half to two times the width of the glabella, curving apart back and outwards in convex arc to eyes but scarcely bending in, posterior branches curving back simply to cut posterior border at about 45° and nearly thrice the width of the glabella at base, posterior border straight and narrow, occipi-

tal furrow distinct, deep and slightly arched towards the posterior end at the centre; the width of the occipital ring slightly more in the centre than at the sides.

Thorax of 12 segments, broad, axis convex less than one third the total width of thorax, gradually tapering backwards; axial rings with faint lateral swellings, pleurae horizontal out to fulcrum beyond which they are gently curved back to end in short free pointed posteriorly directed spines.

Pygidium semitriangular, nearly one quarter the length of thorax, with simple narrow flattened border; anterior width of pygidium is nearly twice its length, axis slightly conical less than one third the width of the pygidium, obtusely pointed, nearly extending to marginal furrow, composed of five rings; lateral lobes gently convex with five pairs of nearly horizontal pleurae, interpleural furrows strong.

Discussion: The specimens correspond to the genus *Hundwarella* in all its cranial morphological details. However, these differ from all the known species of *Hundwarella*.

It differs from *H. personata* in possessing a narrow preglabellar area and anterior border, which is 2:1 in *H. personata*, smaller eye lobes, thin eye ridges and effaced third pair of lateral glabellar furrows, whereas in *H. personata* the lateral glabellar furrow joins with another supplementary furrow to enclose a central band.

The specimens correspond to *H. pisiformis* in having narrow eye ridges, medium-sized eyes and bifurcating third pair of lateral glabellar furrows but differ in the presence of a narrow preglabellar area, in the

ratio of preglabellar area — anterior border, gently curved anterior border (which in *H. pisiformis* is considerably arched forward) and in the first pair of lateral glabellar furrows which are directed anteriorly, whereas in *H. pisiformis* they are straight. From *H. falconi* the specimens differ in possessing a narrow preglabellar area, in the ratio of anterior border of preglabellar area, shape of the glabella and facial suture, a smaller eye, whereas the facial suture in *H. falconi* is more curved just above the glabella; it has a glabella which is greater in length than its width and the first pair of lateral glabellar furrows is perfectly straight.

From *H. kobayashii*, *H. orlovi* and *H. pandei* the specimens differ in the presence of three pairs of lateral glabellar furrows only instead of four as is the case in the above mentioned species. These species also differ from *H. rushtoni* in the length-width ratio of the glabella (the length of the glabella being much greater than its width) and in having thick eye ridges.

The specimens correspond to *H. rasettii* in having three pairs of lateral glabellar furrows, narrow preglabellar area, medium-sized eye and position of eye lobes but differ in the ratio of anterior border and preglabellar area, the width of anterior border being about 1.5 to 1.7 times more than the width of the preglabellar area. *H. rushtoni* also differs in the variable width of the occipital ring, the width being greater at the centre than at the sides and also the occipital furrow being arched posteriorly, whereas in *H. rasettii* the occipital ring is straight and of uniform width.

H. kingi does match in having a narrow preglabellar area, presence of three pairs of lateral glabellar fur-

Dimensions (in mm)

Cranidium	KUF	KUF	KUF	KUF	KUF	KUF	KUF	KUF	KUF	KUF
Total cranial length	585	586	587	588	589	590	591	592	593	594
Posterior cranial width	5.2	6.3	3.0	3.5	5.8	7.5	6.2	4.5	4.2	5.0
Total glabellar length	8.7	10	5.1	5.4	9.8	13	11	7.4	7.0	8.0
Width of glabella at base	3.8	4.2	1.8	2.3	4.5	4.9	4.2	3.2	3.0	3.8
Preglabellar area (length)	3.6	3.9	1.8	2.2	4.3	4.6	4.2	3.1	3.0	3.6
Anterior border (width)	0.4	0.5	0.3	0.4	0.5	0.7	0.6	0.4	0.3	0.3
Width of the cranium at eye lobes	0.6	0.8	0.5	0.7	0.8	1.0	0.8	0.7	0.6	0.5
Pygidium	6.5	8.2	3.8	4.8	8.5	10	9.2	6.5	5.8	7.1
Length of pygidium	—	—	—	—	—	4.0	—	—	—	—
Anterior width of pygidium	—	—	—	—	—	10.0	—	—	—	—
Length of axis of pygidium	—	—	—	—	—	3.2	—	—	—	—
Frontal width of axis	—	—	—	—	—	3.0	—	—	—	—

rows, the third pair being effaced in the middle and nearly equal length and width of the glabella, but differs from *H. rushtoni* in the shape of cranidium and glabella, in having a straight anterior border with the glabella nearly straight at the anterior end, preglabellar area and anterior border of same width, the pattern of lateral glabellar furrows, and the fixed cheek being more convex and elevated in the middle.

Horizon and locality: This form has been collected from *Olenus haimenetensis* Zone in Parahio Valley, Spiti.

STRATIGRAPHIC SIGNIFICANCE:

Hundwarella is the most important faunal element for the stratigraphic correlation of Middle and early Late Cambrian of Asia, because it is widely distributed in several middle and early Late Cambrian sequences of Asia. It is a vital stratigraphic indicator for the correlation of the Cambrian of Spiti and

Kashmir because it is the only polymerid trilobite genus common to both the areas during the late Middle and early Late Cambrian. Secondly, different species of this genus show an evolutionary gradation in successively younger forms (Shah & Raina, in press). The earliest form *H. personata* from the beginning of the Menevian is characterised by a wide preglabellar area, thick eye ridges, large eye lobes, and three pairs of lateral glabellar furrows, of which the third pair counting from the anterior end is bifurcate with both the bifurcating branches transverse, forming a box-like central lobe in the middle. These characters show gradual evolution in the successively younger forms (Fig. 2).

The stratigraphically younger forms from *H. convexa*, *H. transversa* to *H. kingi* in Kashmir and then Spiti forms viz., *H. interpres*, *H. rushtoni* show the preglabellar area narrowing down gradually, the eye ridges becoming thin and eye lobes shortening grada-

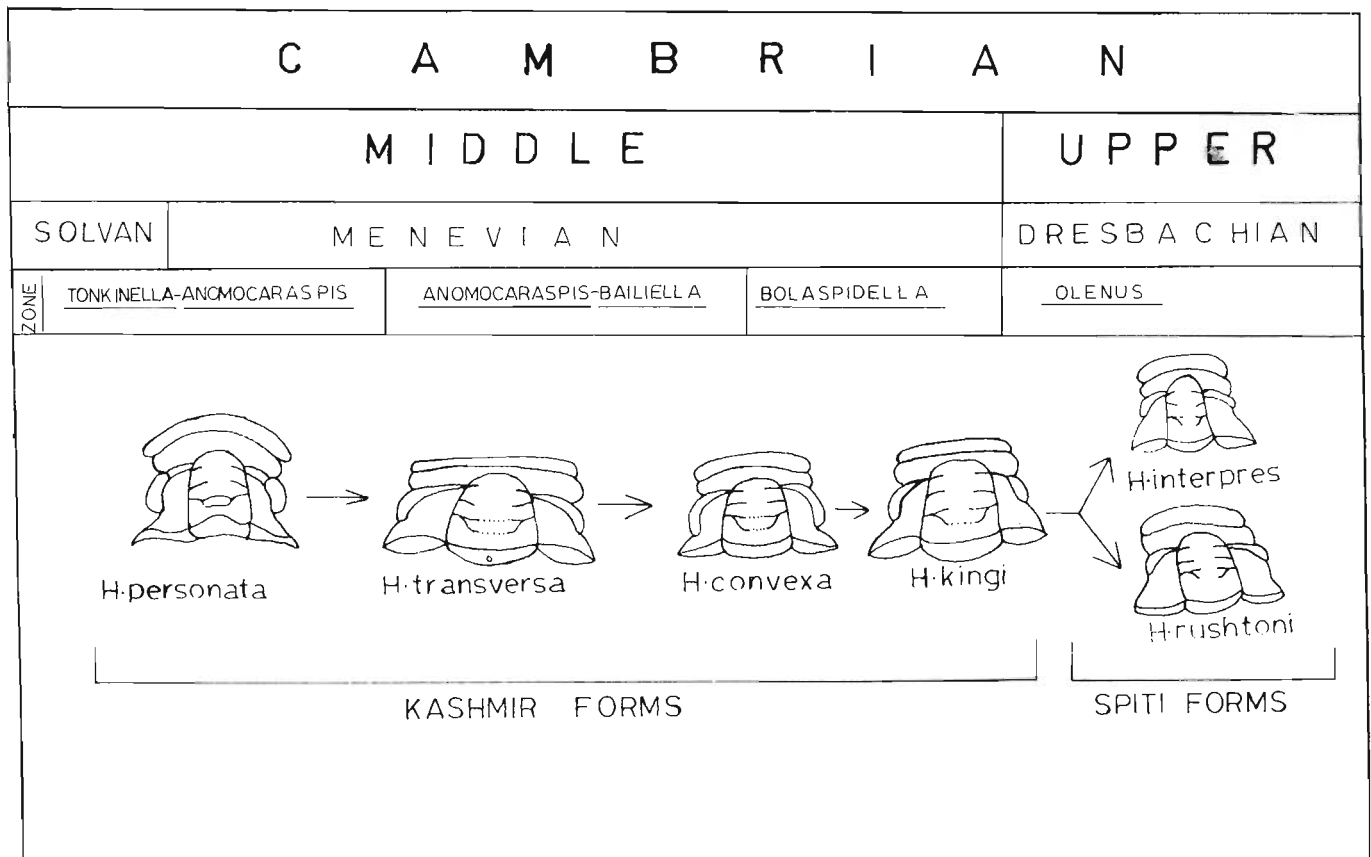


Fig. 2. Evolutionary gradation shown by different species of *Hundwarella* from Himalayan Cambrian.

tionally. The third lateral glabellar furrow is undoubtedly bifid in all the species of *Hundwarella*. However, while both the bifurcating branches are transverse in *H. personata*, in the higher species *H. convexa* and *H. transversa* only the posterior bifurcating branch is effaced in the middle. In *H. kingi* both the bifurcating branches are mesially effaced. Spiti forms viz., *H. interpres* and *H. rushtoni* also have both the bifurcating branches effaced in the middle but, the anterior branch also becomes shorter.

The evolutionary trend discussed here is reflected in the successive appearance of different faunas in Spiti and Kashmir during Cambrian times. A similar pattern is noticeable between the species of *Hundwarella* found in Kashmir and Iran. However, very limited data is available on the species of *Hundwarella* reported from Indo-China and, therefore, no conclusions can be drawn at this stage.

As is well known, most of the trilobite elements in the Cambrian are highly sensitive to facies and particular species tend to be confined to certain facies only. As in many other areas of the world, this is also true of Spiti and Kashmir Cambrian fauna. There are, however, some exceptions, the most important being the agnostids which cut across facies as well as geographical boundaries. Among the polymerid trilobites, within the Himalayan setting, the genus *Hundwarella* has a special significance as it likewise cuts across facies boundaries, which explains its occurrence in different facies in Australo-Asian super-regions. To what extent *Hundwarella* may also have

transgressed geographical boundaries cannot be assessed, since its occurrence outside the Australo-Asian super-region is unknown.

REFERENCES

- CHANG, W.T. 1959. New trilobites from the Middle Cambrian of North China. *Acta Palaeont. Sinica*, **5**(1): 29-31.
- GUPTA, V.J. & SUNEJA, I.J. 1977. New species of *Iranoleesia* from the Cambrian rocks of Kashmir India. *Jour. Palaeont. Soc. India* **20**: 348-352.
- IVSHIN, N.K. 1953. Middle Cambrian trilobites of Kazakastan. *Acad. Nauk. Kazakastan S.S.R.* **2**:
- KING, W.B.R. 1937. Cambrian trilobites from Iran (Persia). *Pal. Ind. Geol. Surv. India, N.S.* **22**: 1-22.
- KING, W.B.R. 1955. In Moore (Ed.), *Treatise on Invertebrate Paleontology* Part 0: 290.
- KOBAYASHI, T. 1944. The Cambrian Formation in the Middle Yangtze Valley and some trilobites contained therein. *Japan Jour. Geol. Geogr.* **19**.
- KOBAYASHI, T. 1962. The Cambro-Ordovician Formations and faunas of South Korea, Part 9. *Jour. Fac. Sci. Imp. Univ. Tokyo Soc. 2* **14**(1): 1-152, pls. 8.
- KOBAYASHI, T. 1967. The Cambrian of eastern Asia and other parts of the continent. The Cambro-Ordovician formations and faunas of South Korea. Part 10 Section C. *Jour. Fac. Sci. Univ. Tokyo*, **14**(3): 381-534.
- MANSUY, H. 1916. Faunas Cambriennes de l' extreme orient meridional. *Mem. Service Geol. de l' Indo Chine*, **5**.
- REED, F.R.C. 1910. Cambrian fossils of Spiti. *Pal. Ind. Geol. Surv. India Ser. 15*, **7**(1): 1-70, pls. 6.
- REED, F.R.C. 1934. Cambrian and Ordovician fossils of Kashmir. *Pal. Ind. Geol. Surv. India. N.S* **6**(1): 1-98, pls. 12.
- SHAH, S. K. & RAINA, ALOK K. (in press). Significance of *Hundwarella* in the Provincial setting of Himalayan Cambrian.

EXPLANATION OF PLATE

PLATE I

<i>Hundwarella transversa</i> n. sp.	
a) Cranidium	x 3.4
b) Cranidium	x 3.2
o) Cranidium	x 3
p) Cranidium (Holotype)	x 3.5
<i>Hundwarella convexa</i> n. sp.	
c) Cranidium	x 3.8
d) Cranidium (Holotype)	x 4
e) Cranidium	x 2.9
f) Cranidium	x 4.5
g) Exoskeleton without pygidium (latex mould)	x 2.5
k) Exoskeleton without pygidium	x 2.5
n) Partially broken cranidium	x 3.5
<i>Hundwarella kingi</i> n. sp.	
h) Cranidium	x 2.8
i) Cranidium (Holotype)	x 3
<i>Hundwarella interpretes</i> (Reed)	
j) Exoskeleton without free cheeks and pygidium	x 3.3
q) Cranidium with two thoracic segments	x 4.5
r) Exoskeleton without free cheeks	x 2.3
s) Cranidium with three thoracic segments	x 2.3
v) Cranidium (partially broken)	x 5
<i>Hundwarella rushtoni</i> n. sp.	
l) Cranidium	x 4
m) Exoskeleton without free cheeks (Holotype)	x 2.3
t) Cranidium with thoracic segment	x 5
u) cranidium	x 4

