Research Article

Genus *Athyrium* Roth (Athyriaceae: Pteridophyta) from Gujarat State

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Abstract

Present study deals with the diversity, distribution and conservation status of the genus *Athyrium* Roth in different climatic regimes of Gujarat state. Five species of *Athyrium* viz., *A. hohenackerianum* T. Moore, *A. falcatum* Bedd., *A. micropterum* Fraser-Jenk., *A. parasnathense* (C.B.Clarke) Ching ex Mehra & Bir and *A. schimperi* subsp. *biserrulatum* (Christ) Fraser-Jenk., were collected from the Gujarat state, of which *A. hohenackerianum* T. Moore is documented earlier. Therefore, occurrence of *A. falcatum*, *A. micropterum*, *A. parasnathense*, and *A. schimperi* subsp. *biserrulatum*, stands as a new distribution records and reported for the first time from Gujarat state. A detailed taxonomic description, photo plates, morphological characters, distribution and comparison of species is provided here for their identification.

Keywords: Gujarat; Athyriaceae; New distribution record; *Athyrium*

Citation


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Introduction

The lady fern genus *Athyrium* Roth (family Athyriaceae) was originally described in 1800 (1) based on *Athyrium filix-femina* (L.) Roth. The generic concept in the Athyroid ferns is always debateable. Many genera viz. *Anisocampium* C. Presl (incl. Kuniwatsukia Pic. Serm.), *Cornopteris* Nakai (incl. *Neoathyrium* Ching & Z.R. Wang) and *Pseudocystopteri* Ching & Z.R. Wang were separated earlier from the genus *Athyrium* Roth. However, recently all these representatives are treated under a single genus *Athyrium* (2-6). It is one of the most diversified genera in the world, having ca. 220-230 species (7), of which ca. 50 species and 17 hybrids are reported from India (8). The pteridological studies were carried out by various researchers in the Gujarat (9-16) and a single species (*i.e.* *A. hohenackerianum* T. Moore) is reported previously from Gujarat state (17).

Since 2013, we initiated the survey for documentation of the pteridophyte diversity in the Gujarat and periodically visiting different parts of the state like wetlands, agricultural fields, hilly regions and plains. Terrestrial ferns growing naturally in shaded, semi-shaded or as a lithophyte on exposed places of rock, on mountain steeps and...
river banks. They were collected from different forests of Saurashtra, central and south Gujarat. On critical study and comparison with available literature collected specimens were identified as *Athyrium falcatum* Bedd., *A. parasnathense* (C.B.Clarke) Ching ex Mehra & Bir, *A. micropterum* Fraser-Jenk., and *A. schimperi* subsp. *biserrellum* (Christ) Fraser-Jenk., belonging to the family Athyriaceae. Perusal of available literature on pteridophyte diversity of Gujarat showed that occurrence of these four ferns were not documented so far in the existing list of the pteridophyte diversity of Gujar (12, 17, 18-20). Therefore, a brief description and photograph (Fig. 1-4) of these four taxa are given as follow for their easy identification.

**Materials and Methods**

Field survey were carried out during the period of 2013-2018 from different forest areas of Gujarat. The collected specimens were pressed using field presser and processed at laboratory. These pressed specimens were poisoned by 4% formalin and affixed on the herbarium sheets by using fevicol glue. Collected specimens were identified with the help of available literature (8, 21-26). Further identity of all species of *Athyrium* were confirmed by comparing with the help of authentic herbarium specimens available in different herbaria, viz. MH, BSI, BLAT and SUK. The voucher specimens were deposited in herbarium of the Department of Botany, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat (BARO).

**Taxonomic treatment**

**Key to the species**

1a. Lamina pinnatifid or pinnatisect .......................... 2
1a. Lamina bipinnate or tripinnate .......................... 3

2a. Lamina pinnatifid, lower pinnae suddenly reduced, pinnae auriculate .............. *A. falcatum*
2b. Lamina pinnatisect, pinnae gradually reduced, pinnae not auriculate .............. *A. micropterum*

3a. Lamina bipinnate, densely scaly stipe and rachis ........................................... *A. hohenackerianum*
3b. Lamina tripinnate, sparsely scaly stipe only .......................... 4

4a. Pinnae apex acute, margin crenate .......................... *A. parasnathense*
4b. Pinnae apex long acuminate, margin dentate ........................................ *A. schimperi* subsp. *biserrellum*


*Athyrium x keralense* Manickam & Irudayaraj, Pterid. Fl. W. Ghats, S. India 238. 1992

**Description:** Plants 20-40 cm height, terrestrial, small-medium sized fern; *rhizome* 1-2 cm long, short, erect, caespitose, scaly; *scales* 2-7 mm long, linear-lanceolate, entire, yellow-brown, acuminate at apex, broad at base, margin entire; *frond* 19-38 cm long, 03-06 cm broad, monomorphic, pinnate-pinnatifid, pale green-green; *stipe* 3-5 cm long, scaly, pale green at young, grooved; *scales* similar to the rhizome scales; *lamina* 16-33 cm long, 03-06 cm broad, dark green-pale green, unipinnate-pinnatifid, linear-lanceolate, apex acuminate, glabrous, glossy; *rachis* sparsely scaly, straminaceous, flat-round; *pinnae* 3-5 cm long, 1-2 cm broad, 12-25 pairs, subopposite-alternate, dentely lobed, basal lobes auriculate, acute at apex, broad at base; *veins* distinct above and below, forked, reaching to the margin; *sori* 2.5-4 mm long, 0.5-1.5 mm broad, crescent or hook like, indusiate, median; *indusia* 2.5-4 mm long, 0.5-1.5 mm broad, thin membranaceous, yellow-brown, hook like, margin dentate, persistent; *sporangia* 200-600 μm in diameter, numerous, composed of 13-18 annular cells, sub-globose, brown; *spores* 40-60 μm in diameter, monolette, plano-convex in lateral view and elliptic in polar view.

**Distribution:** India (Uttarakhand, Sikkim, Meghalaya, Tripura, Mizoram, Orissa, Parasnath Hills, Madhya Pradesh, Rajasthan, Maharashtra, Kerala), Nepal, Myanmar [Burma]. (Gujarat: Ahwa, Dang, Don, Dharampur, Kaprada, Mahal, Wilson Hills, Junagadh, Karjan dam, Dediapada and Sagai (common throughout Saurashtra, central and south Gujarat).

**Phenology:** Annual. **Sterile phase:** July-August; **Fertile phase:** August-November

**Conservation status:** *Athyrium falcatum* is known from central, south and Saurashtra forest areas. This species is luxuriously growing in the Dangs, Valsad, Narmada and Junagadh a population of about 100-250 individuals were found and the area of occupancy (AOO) is 250 km². Hence, according to IUCN categories and criteria (27), it is assessed as Least Concerned (LC) species.


**Type:** India, North-West Himalaya, Nainital Dt.

**Description:** Plants 15-40 cm in height, terrestrial, medium sized fern; *rhizome* 1-2 cm long, short,
erect-suberect, scaly; scales 1.5-6 mm long, 1-3 mm broad, yellow-brown, linear-lanceolate, long acuminate apex, broad at base, margin entire; fronds 14-38 cm long, 3-6 cm broad, broadly lanceolate, pinnate-pinnatisect, acuminate, herbaceous, green-pale green; stipe 3-10 cm long, scaly, pale green-brown, grooved, sharper than lamina; scales same as like rhizome scales; lamina 11-28 cm long, 3-6 cm broad, pinnate-pinnatisect, broadly lanceolate, apex acuminata, green-pale green, glossy, glabrous, lowest pinnae reduced; pinnae 3-6 cm long, 1.3 cm broad, 12-25 pairs, 20-30 pairs, ovate-deltoid or lanceolate, acuminata-subacutum apex, broad at base, margin crenate, sessile to short stalked, subopposito-alternate, deeply incised; veins forked, slightly distinct above and below; sori 2-4 mm long, 0.4-1.5 mm broad, indusiate, straight-hook like, along the veins, brown, median or sub-median; indusia 2-4 mm long, 0.4-1.5 mm broad, thin membranaceous, yellow-brown, straight-hook like, margin wavy or crenate; sporangia 200-500 µm in diameter, numerous, covered with 10-17 annular cells, sub-globose, stalked; spores 40-60 µm in diameter, monolete, plano-convex-in lateral view and elliptic in polar view.

**Distribution:** India (Gujarat, Maharashtra). (Gujarat: The Dangs, Narmada, Tapi and Valsad).

**Phenology:** Annual, **Sterile phase:** July-August; **Fertile phase:** August-November

**Ecology and conservation status:** *Athyrium micropterum* is known from the Dangs Forest areas. This species is luxuriously growing in the south Gujarat, a population of about 80-150 individuals were found and the area of occupancy (AOO) is 250 km². Hence, according to IUCN categories and criteria (27), it is assessed as Least Concerned (LC) species.

**Specimen Examined:** INDIA, Maharashtra, Satara Dt., Mahabaleshwar, alt 1200 m., 13/10/1968, M. R. Almeida, 711 (BLAT); Karnataka, North Kanara, 25/11/1950, Famandezee, 1880 (BLAT); Andhra Pradesh, East Godavari Dt., Valamum, alt. 550 m., 23/12/1993, Mohanan, 170337 (MH); Gujarat, The Dangs Dt., Chinchli, 807 m, 25/08/2017, R.N. Kachhiyapatel & K.S. Rajput, 249 (BARO).


*Allantodia hohenackeriana* Kunze, Farnkr.2. 63 t. 126. 1850.


**Type:** India, Karnataka, Canara.

**Description:** Plants 10-35 cm in height, terrestrial, medium sized herb; rhizome 1-2 cm, sub-erect, densely scaly at apex; scales 2-6 mm long, 0.5-2 mm long, linear-lanceolate, concolor, apex acuminate, margin entire; frond pinnatifid-bipinnate, elliptic lanceolate; stipe 03-10 cm long, densely scaly base, sparsely above; scales same as on the rhizome scales; lamina 06-23 x 3-6 cm, longer than stipe, pale green-green, elliptic-lanceolate, apex long acuminate, lower pinnae reduced, rachis sparsely scaly; pinnae ovate-lanceolate, apex acuminate, base broad, margin serrate, sessile to short stalked, opposite-subopposite; veins slightly distinct above and below, forked, reaching to the margin; sori 1.5-6 mm long, 0.6-2.5 mm broad, indusiate, straight or J-shaped, along the veins, median or sub-median; indusia 1.5-6 mm long, 0.6-2.5 mm broad, straight or J-shaped, thin, membranaceous, brown; sporangia 200-500 µm in diameter, numerous, 10-17 annular cells, sub-globose, brown; spores 45-65 µm in diameter, monolete, plano-convex to slightly concavo-convex in lateral view and elliptic in polar view.

**Distribution:** India (Andhra Pradesh, Chhattisgarh, Goa, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu), Sri Lanka. (Gujarat: common throughout Junagadh, Central and South Gujarat)

**Phenology:** Annuals, **Sterile phase:** June-July; **Fertile phase:** July-November

**Ecology and conservation status:** *Athyrium hohenackerianum* is known from Saurashtra, central and south Gujarat forest areas. This species is luxuriously growing in the central, Saurashtra and south Gujarat, a population of about 500-600 individuals were found and the area of occupancy (AOO) is 500 km². Hence, according to IUCN categories and criteria (27), it is assessed as Least Concerned (LC) species.

**Specimen Examined:** INDIA, Maharashtra, Kolhapur Dt., Dajipur, 700 m., S. S. Patil, (SUK); Ratnagiri Dt., Dapoli, 100 m., M. V. Masal, (SUK); Satara Dt., Koyanagar, 800 m., V. V. Jadhav (SUK); Mahabaleshwar, alt. 1200 m, 06/09/1954, P. V. Bole, 1116 (BLAT); Gujarat, Narmada Dt., Sagai, 369 m, 19/09/2014, R.N. Kachhiyapatel & K.S. Rajput, 64 (BARO); The Dangs Dt., Chinchli, 807 m, 25/08/2017, R.N. Kachhiyapatel & K.S. Rajput, 251 (BARO).


*Asplenium filix-femina* (L.) Bernh.var. parasnathensis C.B.Clarke, Tr. Linn.Soc. II, 1: 493, 14 t. 61, C 2 1880.

Type: India, Parasnath, Chota Nagpore.

Description: Plants 15-45 cm in height, terrestrial, medium sized fern; rhizome 1-2 cm, short erect-suberect, caespitose, scaly; scales 1-5 mm long, 0.5-2 mm broad, yellow-brown linear-lanceolate, acuminate at apex, broad at base, margin entire; frond 14-43 cm long, 3-7 cm broad, herbaceous,
bipinnate-bipinnatifid, broadly lanceolate; **stipe** 3-10 cm long, pale green-brown, grooved, densely scaly at base; scales same as like rhizome scales; **lamina** 11-33 cm long, 3-7 cm broad, broadly lanceolate, apex acuminate, dark green-green, glabrous, glossy; **pinnae** 3-7 cm long, 2-3 cm broad, 15-25 pairs, deltoid-lanceolate, sessile to short stalked, subopposite-alternate, acuminate at apex, broad at base, margin crenate; **veins** forked, slightly distinct above and below; **sori** 1.5-5 mm long, 0.5-2 mm broad, indusiate, linear-hooked, two rows; **indusia** 1.5-5 mm long, 0.5-2 mm broad,
thin, membranaceous, linear or hooked, median or sub-median, persistent; **sporangia** 200-600 µm, composed of 12-18 annular cells, sub-globose; **spores** 45-60 µm in diameter, monolete, plano-convex to concavo-convex in lateral view and elliptic in polar view.

**Distribution**: India (Bihar, Gujarat, Karnataka, Maharashtra, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand). (Gujarat: Ahwa, Dang, Don, Dharampur, Girnar, Kaprada, Mahal, Wilson Hills, Karjan dam, Dediapada, Sagai).

Fig. 4. *Athyrium schimperi*: A: Plant, B: Frond dorsal (left) and ventral (right) view, C: Stipe base, D: Stipe base scale, E: Pinna, F: Sori, G: Indusium, H: Sporangium, I: Spore. **Scale bar**: B = 2 cm, C = 2 mm, D = 1 cm, E = 1 cm, F = 500 µm, G = 250 µm, H = 125 µm, I = 10 µm.
**Phenology:** Annual, **Sterile phase:** July-August; **Fertile phase:** August-November.

**Conservation status:** *Athyrium parasnathense* is known from Valsad, Narmada, Dang, Shoolpaneswar, Ratanmahal and Junagadh forest areas. This species is luxuriously growing in the Saurashtra, central and south Gujarat, a population of about 100-350 individuals were found and the area of occupancy (AOO) is 250 km². Hence, according to IUCN categories and criteria (27), it is assessed as Least Concerned (LC) species.

**Specimen Examined:** INDIA, Maharashtra, Satara Dt., Patan, 800 m, 20/08/2013, S. M. Patil & M. M. Dongare, 1067 (SUK); **Gujarat**, Junagadh Dt., Girnar hills, 667 m, 24/09/2017, R.N. Kachhiyapatel & K.S. Rajput, 250 (BARO).


*Type:* China, Yunnan.


**Description:** Plants 20-45 cm in height, medium sized herb; **rhizome** 1-2 cm long, short creeping-suberect, scaly; **scales** 1-5 mm long, 0.5-2 mm broad, yellow-brown, liner-lanceolate, acuminate at apex, broad at base, margin entire; **frond** 19-43 cm long, 5-10 cm broad, monomorphic, pinnate-bipinnate, ovate-lanceolate, herbaceous, dark green-green; **stipe** 4-10 cm long, shorter than lamina, densely scaly at base, sparsely above, grooved; scales same as like rhizome scales; **lamina** 15-33 cm long, 5-10 cm broad, ovate or broadly lanceolate, apex acuminate, lowest pinnae reduced, glabrous, glossy; **pinnae** 3-7 cm long, 1-3 cm broad, 3-15 pairs, ovate to lanceolate, long acuminate apex, cuneate base, margin crenate, short stalk-sessile, subopposite-alternate; **veins** forked, distinct above and below; **sori** 2-4.5 mm long, 0.5-2 mm broad, indusiate, linear or J-shaped, along the veins, median or sub-median; **industria** 2-4.5 mm long, 0.5-2 mm broad, thin membranaceous, persistent; **sporangia** 200-600 µm in diameter, numerous, composed of 10-18 annular cells, sub-globose; **spores** 40-65 µm in diameter, monolete, plano-convex in lateral view and elliptic in polar view.

**Distribution:** Bhutan, China, India, Myanmar, Nepal, Pakistan, Tibet (Arunachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Nagaland, Rajasthan, Sikkim, Uttarakhand, West Bengal). (Gujarat: Dangs).

**Phenology:** Annual, **Sterile phase:** July-August; **Fertile phase:** August-November

**Ecology and conservation status:** *Athyrium schimperi* subsp. **biserrulatum**, is known only from the Dangs forest areas. A population of about 10-20 individuals were found and Area of occupancy (AOO) is 5 km². However, other wildlife areas of the state are yet to be explored wholly and we presume that the species might be spread in similar ecological conditions. Thus, more floristic surveys are required to determine and document the full range of distribution of *A. schimperi* subsp. **biserrulatum**. Therefore, according to IUCN (27) criteria, at present this species is considered as data deficient (DD).

**Specimen Examined:** INDIA, **Gujarat**. The Dangs Dt., Borigaotha, 381 m, 05/10/2014, R.N. Kachhiyapatel & K.S. Rajput, 81 (BARO).

**Discussion**

First documented record of pteridophyte from Gujarat state (i.e. *Ceratopteris thalictroides* (L.) Brongn.) goes back to a century ago (9), but studies on this group became neglected thereafter. *A. solenopteris* is reported from Girnar Hills and other forest of the Saurashtra regions (11). Our repeated visits in last 6 years could not relocate the species from Girnar hills. Therefore, it appears that identification of this species might be mistaken for the species *A. parasnathense* (which we collected from Girnar hills). Moreover, the occurrence of *A. solenopteris* in Girnar is erroneous because it is endemic to south India and reported only at high altitude (i.e. above 1500 m) (26). Nevertheless, Girnar hills are considered as one of the tallest hills from the state that has maximum altitude of 1000 m.

In the present study, five species of *Athyrium* viz., *A. hohenackerianum*, *A. falcatum*, *A. micropterum*, *A. parasnathense* and *A. schimperi* subsp. **biserrulatum** were collected. Amongst these *A. falcatum*, *A. micropterum*, *A. parasnathense* and *A. schimperi* subsp. **biserrulatum**, are reporting as new distributional record for Gujarat state. Morphologically, *A. falcatum* and *A. micropterum* are closely related species. However, *A. falcatum* having pinnatifid lamina, suddenly reduced lower pinnae with auriculate pinnule whereas *A. micropterum* is having pinnatisect lamina, gradually reduced lower pinnae with or without auriculate pinnule. Similarly, *A. hohenackerianum*, *A. parasnathense* and *A. schimperi* subsp. **biserrulatum** are closely related species. However, *A. hohenackerianum* is having bipinnate lamina, densely scaly stipe and rachis, whereas *A.
paras Nathense is having bipinnate to tripinnate lamina, sparsely scaly stipe only, pinnae with dentate pinnule and long acuminate apex and A. schimperi subsp. biseriulatum is having tripinnate lamina, sparsely scaly stipe only, pinnae with acute-obtuse apex.

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Authors contribution

RNK and SMP collected the specimens from the field and wrote the initial draft of the manuscript, KSR supervised the project while revision of the manuscript is done by KSR and VMR. All the authors approved the final manuscript.

Competing interest

Authors declare that we have no competing interest.

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