

## DIVERSITY OF FRESH WATER ALGAE FROM THE NULLAH OF TAKHT BHAI, DISTRICT MARDAN, KHYBER PAKHTOON KHAWAH PROVINCE, PAKISTAN

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### ABSTRACT

Twenty two genera and 30 species belonging to Cyanophyceae (5 Genera and 8 spp.), Charophyceae (one genus and one species), Chlorophyceae (4 Genera and 5 spp.) and Bacillariophyceae (12 Genera and 16 spp.) were recorded from the Nullah of Takht Bhai, District Mardan, Khyber Pakhtoon Khawan, Pakistan.

**Key Words:** Fresh water, algae, Diversity, Nullah, Takht Bhai, Mardan, Pakistan.

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### INTRODUCTION

Takht Bhai Hill is situated on Mardan Malakand Road at around 15 km of west of Mardan. It is located between 34° 05' to 34° 32' N Latitude and 71° 48' to 72° 25' E longitudes. Literary Takht Bhai means spring on flat surface of the hill. Spring still exists the west side of the hill. The ancient Buddhist monastery is situated at height of 5500 ft asl. These remains are most amazing and imposing relics of Buddhism in Pakistan. Dating back from 2BC to 5 AD scattered over 32.9 hectares. A Nullah starts at the basin of Takht Bhai ruins and passes through town and ultimately covers a distance of 45 km and join river Kabul.

Fresh water algae of different area has been reported by Sarim & Ayaz (2000); Nawaz & Sarim (2004); Sarim & Zaman (2005); Khair un Nisa & Sarim (2006); Akhtar & Rehman (2009); Sarim *et al.* (2009, 2010); Zaman *et al.* (2009); Hussain *et al.* 2009, 2010 a, b). The area was not previously studied and it was first attempt to study the diversity of the forth mentioned habitat with special emphasis on the variation with resource gradient distances. The present study is addition to the checklist of phycoflora of Mardan District.

### MATERIALS AND METHODS

The studies were conducted in summer and different habitats were selected for samples collection. The samples were collected in 15 different sites at distance of one kilometer, starting from Takht Bhai ruins to Charsadda road. The samples were put in glass bottles and were added 1-2 drops of 3 % formalin to preserve them. The samples were identified after Desikachary (1959), Prescott (1951), Tiffany & Britton (1952) and Transeau (1951).

### RESULTS AND DISCUSSION

Thirty species belonging to 22 genera were found in the Takht Bhai Nullah. They comprised of Cyanophyceae, Charophyceae, Chlophyceae and Bacillariophyceae. Class Cyanophyceae represented 5 genera and 8 species. Each of the genera *Gleocapsa* and *Oscillatoria* had one species. *Nostoc*, *Phormidium* and *Lyngbya* had two species. Charophyceae was represented by *Chara schweinitzii* only. Chlorophyceae was represented by 4 genera and 5 species. These were *Cladophora*, *Mougeopsis*, *Oedogonium*, *Spirogyra* and *Ulothrix*. Each genus was represented by single species. Bacillariophyceae had twelve genera with 16 species which included *Caloneis*, *Cocconeis*, *Cymbella*, *Diatoma*, *Frustulia*, *Gomphonema*, *Mastogloia*, *Nitzschia*, *Stauroneis*, *Synedra*, *Fragilaria*, and *Pinnularia*. These various species have been reported from various water bodies of the province during different seasons. Zaman & Sarim (2005); Sarim & Zaman (2005); Sarim & Zaman (2005), Zaman *et al.* (2009); Sarim *et al.* (2009, 2010); Hussain *et al.* (2009, 2010a,b). Generally, as water flow from resource the diversity decreases. Proximity, and distance from settlements were the two important factors that determine phyco diversity. It is because as water flows, the pollutants of various kinds are added continuously which not only make it and deficient in O<sub>2</sub> turbid it but also and reduce the diversity of algae.

Taxonomic descriptions are given in detail in the following.

#### A. Class Cyanophyceae

### 1. *Gloeocapsa pleurocapsoides* Novacek

*Gloeocapsa* is colonial alga. The colonies are microscopic and more or less spherical or irregular in shape. These are homogeneous and dull green or pale blue in color. The cells ranged 5 – 10 µm in diameter. The cells are closely arranged and either elongated or angular, sheath thin, firm, simple, color yellowish brown or brownish in the peripheral part 2-3 µm thick and lamellated, 3-4 lamellae.

### 2. *Oscillatoria chalybea* var. *insularis* Gardner

Thallus is dark blue green in color, cells 8-13×3.6-8 µm, trichomes straight or sometimes perverted, slightly tapered at cross-walls, gradually tapering for a long distance from the hooked or bent apex, terminal cell somewhat elongate and broadly rounded, blue-green to dark blue-green becoming blackish green in mass. Trichome ends bent into a sickle-shaped, 6.4-7.2 µm broad as long as or shorter than broad.

### *Phormidium*

Trichomes unbranched, cylindrical, enclosed by a gelatinous sheath, partially or entirely confluent, sometimes coated with calcium carbonate not closed at the apices, Plant mass aquatic, sub-aerial composed of nearly parallel or densely interwoven trichomes, generally forming an intensive stratum, rarely solitary, apex various, sometime capitate, often calyptra.

#### Key to species

- + Thallus dark green..... *P. foveolarum*
- Thallus leathery, purple to brownish..... *P. purpurascens*

### 3. *Phormidium foveolarum* (Mont) Gomont

Thallus thin, dark green; trichome flexuous, constricted at the cross- walls, at the ends not attenuated, about 1.4 µm broad, pale blue green; sheath colorless, diffuent in an amorphous gelatinous mucilage, cells nearly quadrate or somewhat shorter than broad, 0.8-1.8 µm long, septa not grounded; and cell rounded, calyptra absent.

### 4. *Phormidium purpurascens* (Kütz) Gomont.

Thallus compact leathery, purple to brownish violet; Trichome strongly bent, knotted, not constricted at the cross walls, ends not attached, 1.5-2.5 µm broad, dark violet; sheath more or less diffuent; cells nearly quadrate or up to nearly two times longer than broader, 2-4.5 µm long, cross-walls marked by two granules on either side; end to cell rounded, calyptra absent. In a cement water course near a tap, attached and on stones in a pond.

### *Nostoc*

*Nostoc* found on stoney walls and is abundant in colonies after monsoon rain. Thallus is mucilaginous and is rounded in shape. Later its form changes to foliose, globose, bulbous. Colonies may be solid or hollow. Trichomes torulose; cells lower, spherical, barrel shaped or cylindrical.

#### Key to species

- + Trichome 2.5 µm broad ..... *N. ellipsosporum*
- Trichome 4 µm broad ..... *N. calcicola*

### 5. *Nostoc ellipsosporum* (Desm.) Rabenh.

Thallus is irregularly stretched, attached to the substratum by the lower surface, filaments flexuous, loosely tangled; trichomes about 4 µm broad, light blue green, cells elongated, heterocysts sub spherical, or oblong, 6-7 µm broad, 6-4 µm long.

6. *Nostoc calcicola* Brebisson ex Born. et Flah.

Thallus is mucilaginous and slightly different, extended, olive, gray or blue green, often up to 5 cm in diameter, filament loosely entangled; sheath mostly indistinguishable or distinct only at periphery of the thallus, colorless or yellowish brown; trichome 2.5 µm broad, cells barrel shaped, sub spherical, rarely longer than broad.

***Lyngbya***

Thallus is unbranched, cylindrical, straight, bent or perverted, solitary or densely entangled into floccose masses, or epiphytic; sheaths firm, generally hyaline but sometimes brownish or yellowish with age, often lamellose, usually extending beyond the trichomes, trichomes solitary, obtuse or sometimes apically assuaged, sometimes constricted at cross-walls; cells contents homogeneous, granulose, variously colored.

**Key to species**

- +Trichome 12 -17 µm broad and constricted at cross wall..... *L. connectens*  
 -Trichome 8-12 µm broad and not constricted at cross wall..... *L. kashyapii*

7. *Lyngbya connectens* **Bruhl et Biswas**

When dry shining and dark green; filaments straight or nearly so, lying parallel to each other, stratum extensive, about 1 mm thick, the trichomes often creep out of their entire sheath, sheath at first delicate and colorless, but later when old, becomes firm and brownish, 1.5-2 thick, nearly lamellate with 2-3 lamellae. Trichomes 12-17 µm broad, not constricted at the cross walls, slightly thickened at the apex, cells about 1/6 as long as broad, 2-2.5 µm long, dissepiments granulated.

8. *Lyngbya kashyapii* **Ghose**

Thallus expanded, dull purple; filament coiled, densely intricate, sheath firm, thick, dull blue or purple, smooth, chitinous; trichomes 3-4 µm broad, not constricted at the cross wall, non granulated often oblique or curved, end cell rounded, not capitates and no calyptras.

**B. Class Charophyceae**

1. *Chara schweinitzii* A. Braun

Plants olive green, 10-15 cm high; stem long jointed, with a single whorl of stipulodes at the node, which also gives rise to 8-11 leaves; internodes of both stem and leaves uncorticated.

**C. Chlorophyceae**

1. *Spirogyra crassa* Kuetzing

Filament rough, stout, feeling glassy to the touch; vegetative cells. Cells size ranged 133 -160 µm in diameter, Cells quadrant or 2 times the diameter in length, with flat surface end walls; chloroplast 6-12 (usually 8-10), small, making ½ to 1 turn; forming dark green masses of coarse filaments in quiet waters.

2. *Ulothrix tenerrima* Kuetzing

Filaments free floating or attached; long, or in short sections; composed of cylindrical, relatively short cells with constrictions at the cross walls. Chloroplast an irregularly folded plate, ½ the length of the cell, with 1 pyrenoid. Cells 7.5-10 µm in diameter, 10-15 µm long.

3. *Ulothrix variabilis* **Kuetzing**

Filaments long, slender and entangled forming cottony masses. Cells cylindrical, without constrictions at the cross walls. Chloroplast a folded, parietal plate,  $\frac{1}{2}$  to  $\frac{2}{3}$  the length of the cell, with 1 pyrenoid (or 2 pyrenoids). Cells 4.5-6  $\mu\text{m}$  in diameter and up to 15  $\mu\text{m}$  long.

4. *Oedogonium priugsheimii* Cramer

Female vegetative cell 14-20 x 28-100  $\mu\text{m}$ , male 12-16 x 24-64  $\mu\text{m}$ .

5. *Microspora floccosa* (Vauch) Thuret

Walls relatively thin, sections not always evident in the mid region of the cells. Cells cylindrical or slightly swollen; 14-17  $\mu\text{m}$  in diameter, 22-29  $\mu\text{m}$  long. Chloroplast usually reticulates.

## D. Bacillariohyceae

### *Amphora* Ehrenberg

Cells are sessile with concave faces attached in girdle view, broadly elliptic in outline, with truncate ends, girdles usually separated by several punctate or striate intercalary bands valves lunate, longitudinally asymmetric, transversely striate; axial field strongly eccentric, nearer the concave side of the valve; raphe gibbous, with its central nodule close to the concave margin; chromatophores, single or 2-4.

#### Key to species

- + Striae 6-8  $\mu\text{m}$  in length ..... *A. Mexicana*
- Striae 10 – 13  $\mu\text{m}$  in length ..... *A. ovalis*

1. *Amphora mexicana* A.S

Valve lunate with arcuate dorsal and straight ventral margin. Median lines more or less biauriculate. Axial area not distinct, central area small and rounded on the dorsal side. Dorsal side with a longitudinal line more or less approximate to the median line. Striae 6-8 in 0.01mm, coarsely punctate; puncta 6-7 in 0.01mm. Ventral side entirely covered with somewhat radiate striae.

2. *Amphora ovalis* Kuetzing

Cells are girdle shaped broadly elliptic with truncate ends, 17-63 x 20-110  $\mu\text{m}$ , Valve lunate, with rather blunt poles, ventrally concave, dorsally convex; raphe gibbous; axial area narrow, central area develop only on the ventral side; Transverse striations 10-13 in 10 $\mu$ , convert into ventrally at the poles, radial elsewhere.

3. *Caloneis alpestris* (Grunow) Cleve

Cells are 6-15 x 45-92  $\mu\text{m}$ ; valves linear elliptic, with slightly convex sides and rounded end, transverse striations somewhat radial, 20-24 in 10  $\mu\text{m}$ ; central area small, roundish, central nodule with crescent structures; raphe straight; longitudinal lines distinct.

4. *Diatoma vulgare* Bory

Cells 10x 30 – 60  $\mu\text{m}$ , united into zig-zag colonies with rounded corners and several delicate intercalary bands; valves elliptic-lanceolate, narrowed slightly toward the rounded poles, with very narrow pseudo raphe; costae 6-8 in 10  $\mu\text{m}$ ; transverse striations about 16 in 10  $\mu\text{m}$ .

5. *Diploneis elliptica* (Kuetzing) Cleve

Cells 10-30 × 20-65 µm; Valves broadly elliptic, with large roundly quadrate central nodule with distinct hornes, furrow slender, medially somewhat widened; Transverse costae somewhat radial, 9-13 in 10µ, crossed by numerous irregular longitudinal costae, forming areole 9-14 in 10 µm.

#### 6. *Fragilaria virescens* Ralfs

Cells 5-10x12-120 µm, united in long chains; valves linear, with straight to slightly convex sides. Rounded poles and very narrow pseudoraphe; transverse striations moderately fine, parallel, 12-19 in 10 µm.

#### 7. *Mastoglia smithii* Thwaites

Valves elliptic with pronounced prostrate ends

#### *Navicula* Bory

Cells are solitary and free-floating, sometimes aggregated into irregularly radiating clusters rectangular in girdle view, with smooth girdles and without intercalary bands; valves elongate, usually attenuated toward capitates, rounded or rostrate poles; axial field narrow with distinct, straight raphe and poles and central expansions, nodules small; transverse striations, sometimes somewhat medianly radial; two laminate chromatophores, rarely 4 to 8, infrequently with one or more pyrenoids.

#### Key to species

- + Valves linear..... *N.bacillum*
- Valves lanceolate..... *N.salinarum*

#### 8. *Navicula bacillum* Ehrenberg

Cells 10-20 × 30-80µ, values linear, with straight or convex sides and broadly rounded ends, transverse striations, 12-14 in 10µ at the middle, 18-20 in 10µ at the poles, central area rounded.

#### 9. *Navicula salinarum* Grunow

Cells 8-12 × 23-41 µm; valves lanceolate, with more or less rostrate, often lightly capitates end central area round; transverse striations, medially alternately long and short, radial, 14-16 in 10 µm.

#### 10. *Neidium Neidium productum* (WM.Smith) Pfitzer

Values broadly linear elliptic with narrowed rostate-capitate poles with rounded ends; raphe straight; axial area narrow, usually linear; central area elliptic, widened laterally; striations parallel some times irregular at the centre, evidently punctuate, 16-18 in 10 µm, crossed by more or less parallel longitudinal furrows at varying distances from form margins

#### *Nizschia* Hassall

Cells solitary and free floating or densely clustered in simple or unbranched gelatinous tubes, elongate-rectangular or sigmoid in girdle view, with somewhat attenuated poles, rhombic in cross-section; valves longitudinally asymmetric, very variable in shape; straight, sigmoid, linear, elliptic, somewhat undulate, medially constricted or not, poles acute or rostrate or capitate, often much attenuate; near one margin is a keel with a raphe having small nodules and a row of circular pores opening toward the interior of the cell; transversely striate or punctuate; two chromatophores on the same girdle face.

#### Key to species

- + Striations 16 - 20 in 10 µm..... *N. hungarica*
- Striation more than 30 in 10 µm..... *N. linearis*

### 11. *Nitzschia hungarica* Grunow

Cells  $6-9 \times 20-110 \mu\text{m}$ , valves narrowly linear, with parallel or somewhat concave sides and slightly rostrate poles; striations 16-20 in  $10 \mu\text{m}$ , interrupted by a fairly wide fold; keel punctae 7-9 in  $10 \mu\text{m}$ .

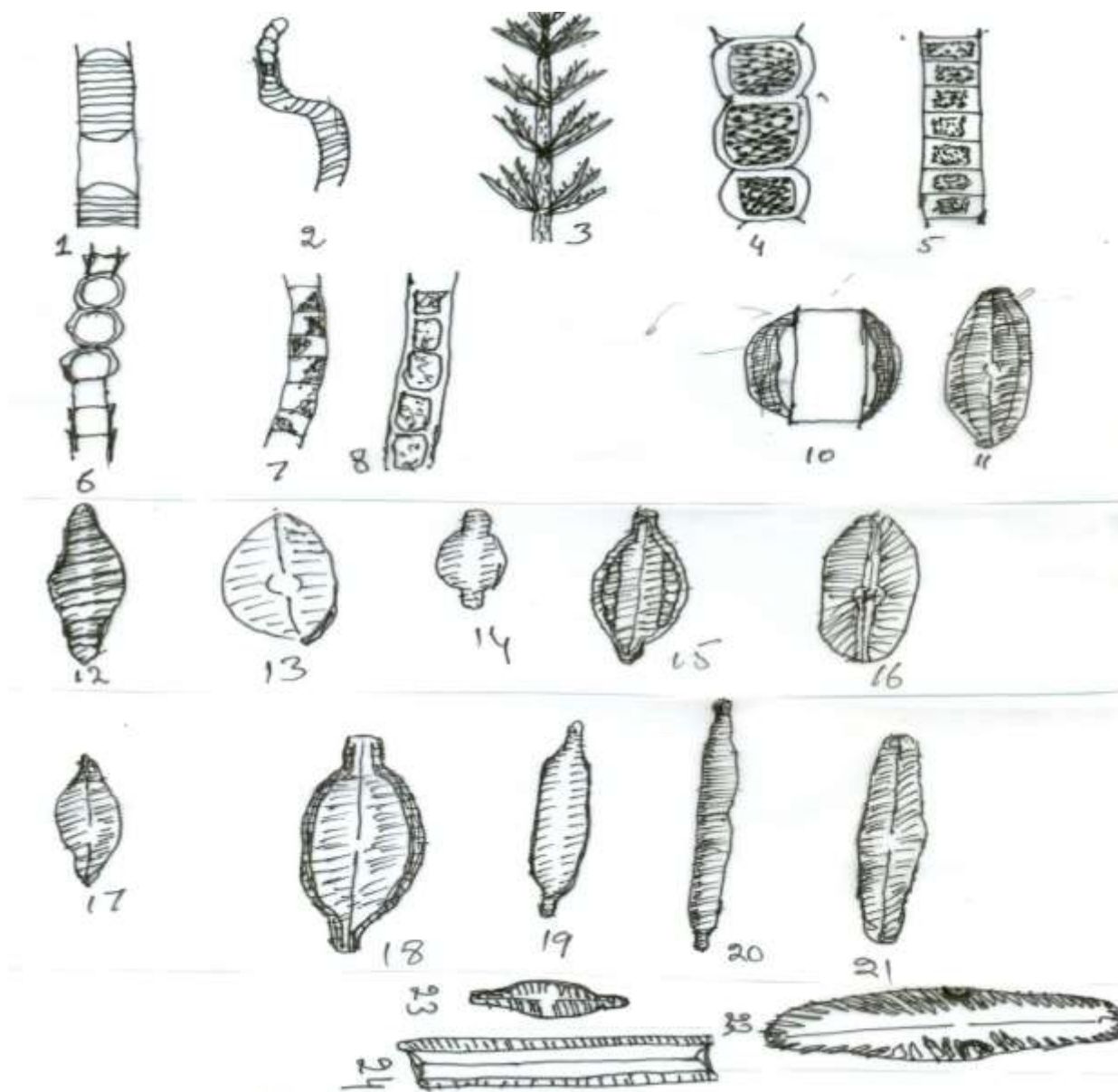


Fig. 1 *Oscillatoria chalybea* var. *insularis* Gardner, Fig. 2 *Ulothrix tenerrima* Kuetzing, Fig. 3 *Chara schweinitzii* A. Braun, Fig. 4 *Phormidium foveolarum* (Mont) Gomont, Fig. 5. *Phormidium purpurascens* (Kutz) Gomont. Fig. 6 *Nostoc ellipsosporum* (Desm.) Rabenh. Fig. 7 *Nostoc calcicola* Brebisson ex Born. et Flah., Fig. 8 *Lyngbya connectens* Bruhl et Biswas, Fig. 9 *Amphora mexicana* A.S., Fig. 10 *Caloneis alpestris* (Grunow) Cleve, Fig. 11 *Diatoma vulgare* Bory, Fig. 12 *Diploneis elliptica* (Kuetzing) Cleve, Fig. 13 *Fragilaria virescens* Ralfs, Fig. 14 *Mastoglia smithii* Thwaites, Fig. 15 *Navicula bacillum* Ehrenberg, Fig. 16 *Navicula salinarum* Grunow, Fig. 17 *Neidium productum* (Wm.Smith) Pfitzer, Fig. 18 *Nitzschia hungarica* Grunow, Fig. 19 *Nitzschia linearis* (Wm.Smith) Grunow, Fig. 20 *Pinnularia appendiculata* (Agendh) Cleve, Fig. 21 *Pinnularia divergens* Wm.Smith, Fig. 22 *Stauroneis anceps* var. *linearis* (Grunow) van Heurck, Fig. 23 *Synedra ulna* (Nitzsch) Ehrenberg.

### 12. *Nitzschia linearis* (Wm.Smith) Grunow

Valves more slender, about  $85 \mu\text{m}$  long; Striations more than 30 in  $10 \mu\text{m}$ ; keel punctae about 11 in  $10 \mu\text{m}$ .

***Pinnularia* Ehrenberg**

Cells are either solitary or free floating, symmetrical, rectangular in girdle view, girdles smooth, valves usually with straight sides, sometimes medially inflated or undulate, generally with broadly rounded poles; axial field usually broad, expanded both polar and medially with complicated straight or sigmoid raphe; costae with internal openings, smooth, radial or transverse, with two longitudinal lines visible in the costate part of the valves. Chromatophores two, laminate, usually with pyrenoids.

**Key to species**

- + Cells with elliptic lanceolate valves, Cells 23-20x50-140  $\mu\text{m}$ ..... *P. divergens*
- Cells with linear lanceolate valves, Cells 4-6x18-36  $\mu\text{m}$  ..... *P. appendiculata*

**13. *Pinnularia appendiculata* (Agendh) Cleve**

Cells 4-6x 18-36  $\mu\text{m}$ ; valves linear lanceolate with nearly straight sides scarcely tapering to broadly rounded ends; axial area narrow slightly lanceolate in the middle with transversely banded central area; transverse striations, some what radial in the middle and convergent at the poles 16-18 in 10  $\mu\text{m}$ .

**14. *Pinnularia divergens* Wm.Smith**

Cells 23-20x50-140  $\mu\text{m}$ ; valves elliptic lanceolate with convex sides and broadly rounded ends; axial area wide.central area extending to the margins and with a conical thickening at each extension; raphe somewhat undulate; transverse striations medially radial and polarly convergent,10-12 in 10  $\mu\text{m}$ .

**15. *Stauroneis anceps* var. *linearis* (Grunow) van Heurck**

Cells 6-8  $\times$  25-130  $\mu\text{m}$ , solitary, without polar septum, valves elliptics to linear lanceolate, with rostate to capitate ends, raphe straight, usually narrow, axial area narrow.

**16. *Synedra ulna* (Nitzsch) Ehrenberg**

Cells 5-9  $\times$  50-350  $\mu\text{m}$ , linear in girdle view with widened extremities, solitry; valves linear to linear lanceolate-gradually narrowed toward the ends, with broadly rounded poles; transverse striations 8-12 (mostly 10) in 10  $\mu\text{m}$ , finely but plainly punctuate; pseudoraphe narrowly linear, with central area varying, often absent.

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