In a population of 100 plants grown at the Nagarkurna University, Botanic garden, two abnormal plants showing the absence of ray florets in all the inflorescences could be located (figure 1). These are similar to their sibs in leaf characters but differ in other parameters (table 1). The capitulum diameter, size of the floret of the outermost whorl and percent seed set are drastically reduced (figure 2, table 1). The disc florets of the mutant are similar in all respects to the normal ones. However, when carefully examined the outer florets of the mutant exhibits a slight tinge of purple and a slight increase in size thereby indicating that the ray florets during ontogeny converted themselves into discs.

<table>
<thead>
<tr>
<th>Character</th>
<th>Control</th>
<th>Mutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>180</td>
<td>185</td>
</tr>
<tr>
<td>Pedicel length (cm)</td>
<td>11.3</td>
<td>15</td>
</tr>
<tr>
<td>Capitulum diameter (cm)</td>
<td>4.28</td>
<td>1.6</td>
</tr>
<tr>
<td>Floret size in the outermost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>whorl (cm)</td>
<td>2.6 × 1.2</td>
<td>1 × 0.4</td>
</tr>
<tr>
<td>Disc floret size (cm)</td>
<td>1.2 × 0.1</td>
<td>1.28 × 0.15</td>
</tr>
<tr>
<td>% Seed set</td>
<td>8.4</td>
<td>2.63</td>
</tr>
</tbody>
</table>

All measurements are the averages of ten except the height of the mutant plant which is an average of two plants.

Cytological studies of the normal and mutant plants revealed normal meiosis with regular formation of 12 bivalents as recorded by earlier workers and 100% pollen fertility. Because of the absence of detectable chromosomal abnormalities and heritability of the character, the abnormality can be ascribed to gene mutation/mutations, which are helpful in bringing out the diversification of the species. The observations further indicate that there is a reversal from derived unisexual condition to bisexual state making the head homogamous. Hence, the present teratological condition in all probability represents an atavistic tendency.

The authors are grateful to Prof. A. S. Rao, Head of the Department of Botany for facilities. One of us (Z.V) is thankful to the UGC for a fellowship.

21 June 1982


**HYDROCARBON UTILIZATION BY AEROMONAS, ARTHROBACTER, BREVIBACTERIUM, CORYNEBACTERIUM, MICROCOCCUS, MYCOBACTERIUM, Nocardia AND SERRATIA SPP.**

BIDYA B. GHOSH* AND A. K. BANERJEE
Department of Botany, Burdwan University, Burdwan 713 104, India.
*Present address: Lecturer, Kalimpong College, Kalimpong, Darjeeling 734 301.

MORPHOLOGICAL, cultural and biochemical characteristics of 10 bacterial isolates capable of utilizing
hydrocarbons as sole source of carbon, reveal that 2
isolates belong to genus *Arthrobacter*, 2 to *Nocardia*
and one each to *Aeromonas*, *Brevibacterium*, *Coryne-
bacterium*, *Micrococcus*, *Mycobacterium* and *Serra-
tia*. The isolates are studied for biomass formation in
kerosene oil specificities for petroleum hydrocarbons and
fermentation of kerosene by a *Arthrobacter* sp. The
hydrocarbon utilizing ability of the strain *Aero-
monas* is not known previously.

A large number of bacterial isolates capable of utiliz-
ing petroleum hydrocarbons as sole carbon source
have been isolated during the extensive screening pro-
grame. The present communication describes the
morphological, cultural and biochemical characteristics
as well as the growth characteristics on hydrocar-
bons of 10 bacterial isolates belonging to 8 genera.
Bacterial cultures were isolated (by enrichment tech-
nique using a mixture of diesel and kerosene (50:50) as
sole carbon source in a synthetic medium1) from the
soil samples collected from different districts of West
Bengal. The isolates were studied for their morphologi-
cal, cultural and biochemical characteristics using
standard methods2 and identified unto the genus
level. Methodology for studying the growth on
hydrocarbons in shake flasks, cultural conditions,
harvesting of cell mass, etc. were described earlier4.

**Morphological, cultural and biochemical
properties:**

Cells were gram positive except for strains B146 and
B245, non-spore forming, non-capsulated, aerobic,
rods except for strain D104, able to grow at 20 and
37°C. Their optimum temperature for growth was
35°C for strains B146, D104 and M04, 32°C for B010,
H12, H14 and M68 and 30°C for B062, B226 and
B245. Almost spherical cells of D104 were single or in
pair or in irregular grouping. Cells of strains B010 and
B226 were short or long, straight or curved rods,
branched, branches rudimentary, old rods fragments
into short rods. Cells in old cultures of B062 and H14
were cocci, cocci germinate into rods, straight or
curved rods grew in angles in one or more points from
the cocci, young cultures composed of rods only, rods
broken into cocci when grew old and followed a de-
ninite growth cycle from cocci to rods and again cocci.
Cells of M68 were single, aggregated in palisade or
Chinese letter form. Straight or curved rods of M04
and H12 were single or in chains, unbranched. Two
strains M04 and B226 were acid fast positive. Except
B010, B062, H14 and M68 all strains were uniformly
stainable in carbol-fuchsin strain. All the strains were
non-motile except for strains B146 and B245.

Strains produced circular, entire margined, opaque,
laire, non-adherent, raised colonies except B226 and
B245 which were small, punctiform and strain B146 pro-
duce translucent, smooth and mucoid colonies. Except
strains of D104 and M04 rest of the strains had rough
surfaced colonies. Non-diffusible chromogenesis pro-
duced by the strains were magenta red by B245, reddish
gray by M68, red by B226 and reddish brown by H14;
white to gray by B010, B062, D104, H12 and M04. The
colony of strain B146 was colourless but diffuse bluish green
fluorescent colour in the medium. Agar strokes of the
strains were abundant and viscid except for membran-
ous growth of strains B146, B245 and M68. The type
of growth on agar strokes was beaded for B010, B062,
B226, H12 and H14; echinulate for strains B146, M04
and M68 and filiform for rest of the strains. During in
growth in nutrient broth the strains B010, B062, B146,
B226, D104 and M68 formed pellicle and H12 ring on
the top; no surface growth in B245 and M04, abundant
sedimentation in H12, H14 and M68, membranous
growth only in H14 occurred. All the strains grew
abundantly on potato plugs except B245 and D104 and
no growth took place in strains of B146 and M104.

Test for indole production, methyl red reaction, and
voges proskauer reaction were negative for all the
strains except VP positive strains of B146, H12 and
H14; positive catalase test, urease test, nitrate reduction
and gelatin liquefaction were shown by all the strains
except the strains B245 and M68 did not produce
urease, B010, H14 and M68 did not reduce nitrate, and
strains B226, H12, H14, M04 and M68 did not liquefy gelatin.
Starch hydrolysed by the strains of B245, D104, H12,
H14 and M68. No change took place in litmus milk by
strains of B010, H12, M04 and M68; LM coagulated by
strains of B146, B245 and D104; acidic reaction
produced by B245; peptonized by B062, B226 and
H12; reduced by B062, B146 and H12. No gas was
produced by the strains of cultures from arabinose,
glucose, fructose, galactose, lactose, sucrose, maltose,
starch, mannitol and inositol; acid produced from
arabinose only by the strain of B146, from glucose and
fructose by all strains except B062 and M04 from
fructose and H12 from glucose; acid was produced
from galactose, lactose and sucrose by strains of B146,
H14 and M68; from galactose by B226 and D104;
from lactose by B245 and from sucrose by B010, B062,
B226 and B245. Acid was not produced from maltose
by B062, D104 and M04. Acid was produced from
starch by D104 and H12; from mannitol by B010,
B062, B146, H14 and M68, and from inositol by B146,
H14 and M68. The cell size and identification of the
isolates are depicted in table 1 below.

**Growth on kerosene oil:**

The strains were grown in shake flasks in the
medium (loc. cit) containing 2% kerosene at optimum
temperature and the growth was classified in various
categories. The results are depicted in table 1, *Arthro-
bacter* sp. B062 showed highest growth on kerosene
and the degree of kerosene utilization was different for
all the strains.
Table 1

Cell size of isolates and their growth on kerosene

<table>
<thead>
<tr>
<th>Strains</th>
<th>Identified as</th>
<th>Cell size (Um)</th>
<th>Growth on kerosene</th>
</tr>
</thead>
<tbody>
<tr>
<td>B010</td>
<td>Nocardia sp.</td>
<td>1.0-7.0 × 0.4-0.6</td>
<td>+ + +</td>
</tr>
<tr>
<td>B062</td>
<td>Arthrobacter sp.</td>
<td>1.4-4.2 × 0.7-0.8 and 0.5 × 0.8</td>
<td>+ + + +</td>
</tr>
<tr>
<td>B146</td>
<td>Aeromonas sp.</td>
<td>1.4-2.1 × 0.5-0.7</td>
<td>+</td>
</tr>
<tr>
<td>B226</td>
<td>Nocardia sp.</td>
<td>1.5-7.0 × 0.4-0.6</td>
<td>+ +</td>
</tr>
<tr>
<td>B245</td>
<td>Serratia sp.</td>
<td>0.3-0.4 × 1.4-2.2</td>
<td>+</td>
</tr>
<tr>
<td>D104</td>
<td>Micrococcus sp.</td>
<td>1.9 × 1.4-1.9</td>
<td>+</td>
</tr>
<tr>
<td>H12</td>
<td>Brevibacterium sp.</td>
<td>2.4-3.8 × 0.4-0.8</td>
<td>+ + +</td>
</tr>
<tr>
<td>H14</td>
<td>Arthrobacter sp.</td>
<td>1.0-4.2 × 0.7-0.8 and 0.7 × 1.0</td>
<td>+ + +</td>
</tr>
<tr>
<td>M04</td>
<td>Mycobacterium sp.</td>
<td>1.4-7.0 × 0.5-0.8</td>
<td>+ +</td>
</tr>
<tr>
<td>M68</td>
<td>Corynebacterium sp.</td>
<td>2.3-2.5 × 0.4-0.7</td>
<td>+ +</td>
</tr>
</tbody>
</table>

+, definite growth; + +, good growth; + + +, better growth; + + + +, best growth.

Table 2

Substrate specificity of isolates for hydrocarbons

<table>
<thead>
<tr>
<th>Strains</th>
<th>n-Hexane</th>
<th>n-Heptane</th>
<th>n-Octane</th>
<th>n-Decane</th>
<th>n-Tetradecane</th>
<th>n-1-Hexadecane</th>
<th>n-Octadecane</th>
<th>n-Cyclohexane</th>
<th>Phenol</th>
</tr>
</thead>
<tbody>
<tr>
<td>B010</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+ +</td>
<td>+ + + + + +</td>
<td>+ + + + +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>B062</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ + + + + + +</td>
<td>+ + + + + + +</td>
<td>+ + + +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>B146</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+ +</td>
<td>+ +</td>
<td>+ +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>B226</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+ +</td>
<td>+ + + + + +</td>
<td>+ +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>B245</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+ +</td>
<td>+ +</td>
<td>+ +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>D104</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>+ +</td>
<td>+ +</td>
<td>+ +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>H12</td>
<td>±</td>
<td>±</td>
<td>±</td>
<td>+</td>
<td>+ + + + + + +</td>
<td>+ + + + + + +</td>
<td>+ + + + +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>H14</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+ + + + + + +</td>
<td>+ + + + + + +</td>
<td>+ +</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>M04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+ +</td>
<td>+ +</td>
<td>+ +</td>
<td>±</td>
<td></td>
</tr>
<tr>
<td>M68</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+ +</td>
<td>+ +</td>
<td>+ +</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

-, no growth; +, doubtful growth; +, definite growth; + +, good growth; + +, better growth; + + +, best growth.

Substrate specificity for hydrocarbons:

The studies were performed in shake flasks at optimum temperature for 72 hr and the results are given in Table 2. The strains showed a wide range of substrate specificity for the members of the hydrocarbons tested. B062 was selected and studied further on series of n-alkanes and mixed hydrocarbons (Table 3). The train showed highest biomass formation on n-hexadecane and n-octadecane and among the mixed hydrocarbons tested kerosene supported best growth of the strain. In general strain B062 grew better on long chain n-alkanes as compared to the short chain ones.

For comparatively low cost of kerosene and for easy recovery of the cells from fermented broth by solvent treatment and also for the best growth of the organism in kerosene, the substrate was selected for large scale production of cells. The cells contain a high amount of protein (69%) and a favourable profile of essential amino acids as reported earlier.
### Table 3

**Substrate specificity of Arthrobacter sp. B062 for hydrocarbons**

<table>
<thead>
<tr>
<th>Substrates</th>
<th>Dry biomass (g/litre)</th>
<th>Substrates</th>
<th>Dry biomass (g/litre)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>n</em>-Decane</td>
<td>0.7</td>
<td><em>n</em>-Hexadecane</td>
<td>2.61</td>
</tr>
<tr>
<td><em>n</em>-Undecane</td>
<td>1.45</td>
<td><em>n</em>-Octadecane</td>
<td>2.62</td>
</tr>
<tr>
<td><em>n</em>-Dodecane</td>
<td>1.52</td>
<td>Kerosene</td>
<td>2.58</td>
</tr>
<tr>
<td><em>n</em>-Tridecane</td>
<td>1.78</td>
<td>Diesel</td>
<td>2.55</td>
</tr>
<tr>
<td><em>n</em>-Tetradecane</td>
<td>2.45</td>
<td>Straight run gas oil</td>
<td>1.05</td>
</tr>
</tbody>
</table>

The abilities of strains of the genus *Arthrobacter* to utilize petroleum hydrocarbons is well known\(^7\). However, reports on the strains of the genera *Aeromonas* and *Serratia* to utilize petroleum hydrocarbons are scanty in literature, particularly, the utilization of petroleum hydrocarbons as sole source of carbon and energy by the strain of the genus *Aeromonas* was not previously known.

13 April 1982


---

**REGMATODON DECLINATUS (HOOK.) BRID.—A NEW RECORD FOR THE NORTH-WESTERN HIMALAYA, INDIA**

B. D. VASHISTHA AND R. N. CHOPRA

Department of Botany, University of Delhi, Delhi 110 007, India.

During a plant collection trip to Himachal Pradesh, India, in October 1981, one species of *Regmatodon* (Leskeaceae) was collected from a temperate, evergreen, coniferous forest near Manali (c. 2000 m alt.). Subsequently, the species was identified as *R. declinatus* (Hook.) Brid. It is the first record of this species from North-western Himalaya. The morphological features are given below:

The light green plants grow in loose tufts. The main stem is creeping and gives rise to erect branches (figure 1a). The latter are less than 1.5 cm tall. Leaves are dense, imbricate, appressed to the stem in dry condition but erectopatent when moist (figure 1b). These are slightly concave (figure 1c), ovateapiculate (figure 1d), ± 1.5 mm long and ± 0.6 mm wide with entire margin. The costa is single and covers more than half the length. Leaf cells are incrassate and variable in shape (figures 1e-g). Seta arises from lateral perichaetial buds (figure 1h). It is ± 0.9 cm long and is rough, especially below the capsule. Capsule is erect, ovate-cylindrical, ± 2.25 mm long and ± 0.95 mm in diameter. Peristome is double and is deeply inserted. Endostome is much larger than exostome. Spores are brown, round, coarsely papillose with average diameter 26 μm (figure 1i).

---

**Figures 1a-i. Regmatodon declinatus (Hook.) Brid.**

(a) Dry plant; (b) Portion of a wet plant; (c,d) Lateral and surface view of leaf; (e) Leaf apex; (f,g) Cells from middle margin, and base; (h) Portion of gametophyte with sporophyte; (i) Spores.

The genus *Regmatodon* with 14 valid species forms a tropical belt round the globe. As per published records this taxon is represented in India by four...