J. Paleont., 80(3), 2006, pp. 447–454

0022-3360/06/0080-447$03.00

EOCENE CONCHOSTRACANS FROM THE LANEY MEMBER OF THE GREEN RIVER FORMATION, WYOMING, USA

SHEN YAN-BIN,[1] OSCAR F. GALLEGO,[2] H. PAUL BUCHHEIM,[3] AND ROBERTO E. BIAGGI[4]

[1]Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences and State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing 210008, <ybshen@jlonline.com>, [2]Departamento de Biología -Área Ciencias de la Tierra- Paleontología (FACENA- UNNE) y Area Paleontología, (CECOAL-CONICET), Casilla de Correo 128, 3400 Corrientes, Argentina, <ofgallego@hotmail.com>, [3]Laboratory of LimnoGeology, Department of Earth and Biological Sciences, Loma Linda University, USA, <pbuchheim@univ.llu.edu>, and [4]Ciencias Naturales-Universidad Adventista del Plata, Entre Rios 03103, Argentina, <biaggire@lsmartin.com.ar>

ABSTRACT—Two new species of conchostracans, *Cyclestherioides wyomingensis* and *Prolynceus laneyensis*, belonging to the Cyclestheriidae and Lynceidae, respectively, are described from the Eocene Laney Member of the Green River Formation of Wyoming, USA. These are the first Cenozoic fossil conchostracans to be formally reported from North America. *Cyclestherioides wyomingensis* has a close affinity to the extant *Cyclestheria hislopi*. The latter is a pan-tropical species, found between approximately 30°N and 35°S. Thus, *Cyclestherioides* may indicate that the Laney Member was deposited in a subtropical setting. The conchostracans and associated fauna of the Laney Member suggest that this member was deposited nearshore in a shallow lake. The concept of *Cyclestherioides* is emended and some fossil species referred to this genus are revised.

INTRODUCTION

THE WORLDWIDE record of Cenozoic fossil conchostracans is limited to only a few regions: China, with many localities ranging from Paleocene to Eocene (Hong et al., 1974; Chen, 1975; Chen and Shen, 1979, 1980, 1981; Shen and Chen, 1979; Shen and Zhang, 1979), Mongolia (late Paleocene–early Eocene; Trusova and Badamgarav, 1976), Brazil (Oligocene; Gallego and Mesquita, 2000), and Argentina (late Paleocene and Miocene–Pliocene; Gallego and Mesquita, 2000; Petrulevicius, 2001).

In the present paper, we describe two new species, *Cyclestherioides wyomingensis* and *Prolynceus laneyensis*, assigned to the Cyclestheriidae and Lynceidae, respectively, from the Anvil Wash locality, the Laney Member of the Green River Formation of Wyoming, USA. These are the first Cenozoic fossil conchostracans to be formally described from North America. These fossils were previously assigned with doubt to *Cyzicus* sp. (Buchheim, 1978) and briefly described by Grande (1984). At that time they were the only Paleogene conchostracans reported outside of China, Mongolia, and Brazil. Abundant conchostracan specimens provide a basis for this study of their taxonomy and the relationships between fossil and modern forms.

LOCALITY AND HORIZON

The conchostracan specimens were found in the Laney Member of the Green River Formation at the Anvil Wash study locality, in the Green River Basin of Wyoming (Fig. 1). The site consists of exposures along Anvil Wash banks at 41°05.743N 109°36.169W in Sweetwater County, southwest of Green River, Wyoming.

The Green River Formation accumulated in the lake basins of Utah, Colorado, and Wyoming (Fig. 1). In the Green River Basin, the formation was divided by Roehler (1992) into the following units, in ascending order (Fig. 2): the Luman Tongue, Tipton Shale Member, that interfingers with the Farson Sandstone Member; the Wilkins Peak Member; and the uppermost member, the Laney Member, unique among other things because of the occurrence of conchostracans (Fig. 2). The Laney Member is well known for its exquisitely preserved fossil fish, among other fossils, as well as for its oil shales and clay shales, but the member also contains other siliciclastic and carbonate rocks.

A middle Eocene age has been assigned to the Laney Member based on several fossil evidence. A fossil mammal from the correlative Bridge Formation indicates a Bridgerian age (McGrew, 1959; Roehler, 1973). In addition, a palynomorph assemblage found in equivalent rocks in the northern part of the basin supports an early middle Eocene age for the Laney Member (Biaggi, 2001). More recently, radiometric dating of tuffs of the Green River Formation corroborates a middle Eocene age for this member (Machlus et al., 2002).

The stratigraphic section measured at the Anvil Wash study locality, which is approximately 23 m thick, consists mainly of kerogen-poor, laminated micrites (KPLM) (laminated carbonate rocks of clay-size grains and less than 2% total organic carbon) (Fig. 3). These laminated rocks contain abundant conchostracans, as well as gastropods and ostracodes. Other fossils include the herring *Knightia* (Jordan) (fish) (Buchheim and Surdam, 1981) and plant remains. Alternating with these laminated calcimicrites are thin (usually less than 10 cm thick) layers of dark-colored organic-rich mudstones that contain abundant plant fragments.

In the upper part of the section the conchostracans occur in a cyclic fashion between pulses of quartz-rich sediment. Near the top of the section a unit of papery, laminated calcimicrites contains a fish mass mortality bed and fish coprolites. The uppermost few meters consist of fine-grained siliciclastic rocks capped by Pleistocene coarse-grained deposits.

GLOBAL DISTRIBUTION OF CENOZOIC CONCHOSTRACANS

Cenozoic fossil conchostracans were first recorded in China by Wang *in* Hong et al., 1974. Subsequently, several localities were reported in the world (Chen, 1975; Zhang et al., 1976; Trussova and Badamgarav, 1976; Shen and Chen, 1979; Shen and Zhang, 1979; Chen and Shen, 1980, 1981; Gallego and Mesquita, 2000) (Table 1).

In Asia they were found from the upper Paleocene–lower Eocene and three faunas can be recognized (Zhang et al., 1976; Chen and Shen, 1981). The *Altaestheria* Trussova *in* Trussova and Badamgarav, 1976 from the Nalanburic Formation in the Nemegetin basin of Mongolia are considered to be synonymous with *Fushunograpta* Wang Si'en *in* Hong et al., 1974, based on their small shell configuration and slender and curvate radial lirae sculpture. The Nalanburic Formation yields fossil vertebrates that are regarded as equivalent to the Gashato fauna and thought to be of Late Paleocene age (Trussova and Badamgarav, 1976).

In South America there are three conchostracan horizons. *Tremembeglypta* (Gallego *in* Gallego and Mesquita, 2000) was reported from the Oligocene Tremembé Formation of the Taubaté Group, São Paulo State, Brazil. Petrulevicius (2001) mentioned conchostracans (*Euestheria*? Depéret and Mazeran, 1912) in the

TABLE *1*—Stratigraphical distribution of the Cenozoic conchostracans.

AGE		CHINA	MONGOLIA	WYOMING	SOUTH AMERICA
Pliocene					Fushunograptidae? Loxomegaglytidae?
Miocene	Messinian				
	Tortonian				
	Serravallian				
	Langhian				
	Burdigalian				
	Aquitanian				
Oligocene	Chattian				*Tremembeglypta*
	Rupelian				
Eocene	Priabonian			*Cyclestherioides* *Prolynceus*	
	Bartonian				
	Lutetian				
	Ypresian	*Paraleptestheria menglaensis* f.			
Paleocene	Thanetian	*Fushunograpta changzhouensis* f. *Perilimnadia* f.	*Fushunograpta* (=*Altaestheria*)		Euestheriidae?
	Selandian				
	Danian				

(f.=fauna)

Maíz Gordo Formation (late Paleocene) in Salta Province, Argentina. Neogene conchostracans in the Upper Member of the San Roque Formation in San Luis, Argentina, can be identified as two taxa, probably belonging to the Fushunograptidae and Loxomegaglyptidae (Gallego and Mesquita, 2000).

In Gemany middle Eocene conchostracans were reported from the Lake Messel (Richter and Baszio, 2001), but have not been formally described. However, as far as is known no credible Quaternary fossil conchostracans have yet been reported anywhere in the world. Thus it can be seen that the conchostracans of the Laney Member are a new Eocene assemblage (*Cyclestherioides–Prolynceus*) belonging to Cyclestheriida and Laevicaudata, respectively. They have a close affinity to the extant *Cyclestheria* Sars, 1887 and *Lynceus* Müller, 1776 (via Barnard, 1929).

SYSTEMATIC PALEONTOLOGY

All illustrated specimens came from the Laney Member of the Green River Formation at Anvil Wash section, Sweetwater County, Wyoming, and are housed in Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS 134166–134186) and in Palaeozoological Collection of the Facultad de Ciencias Exactas y Naturales y Agrimensura, UNNE, Corrientes, Argentina (PZ-CTES N° 7340–7350).

Order CONCHOSTRACA Sars, 1867 (*via* Tasch, 1969)
Suborder CYCLESTHERIDA Sars, 1899 (*via* Martin and Davis, 2001)
Family CYCLESTHERIIDAE Sars, 1899 (*via* Tasch, 1969)
Genus CYCLESTHERIOIDES Raymond, 1946, emended, Shen and Gallego

Emended diagnosis.—Carapace thin, subcircular through subovate, umbo subterminal or subcentral, a few fine or weak growth lines, more or less equal width growth bands, small reticulate sculpture.

Discussion.—Fossil *Cyclestherioides* was first recognized in the Upper Permian of Australia (Raymond, 1946). Subsequently, many authors ascribed species to this genus. However, most of the species possess thick valves, obvious growth lines, and numerous, even, narrow, growth bands, although they do share a subcircular outline and subcentral umbo, which are characteristics of *Cyclestherioides*. Novojilov (1958, 1960) placed *Cyclotunguzites* Novojilov, 1958, *Wetlugites* Novojilov, 1958, and *Spaerestheria* Novojilov, 1954 in the Cyclestheriidae based on their subcircular configuration, but the first two genera have a large umbo, which is a key character of the Palaeolimnadiidae, and the last genus has numerous well-developed growth lines and narrow growth bands. All three genera possess thick valves. *Cyclestheria krivickii* (Novojilov, 1958, p. 35, fig. 32, pl. 3, fig. 35) from Tatarian, Guff Khatanga, Russia, does not fit the type of valve of extant *Cyclestheria* in terms of carapace configuration and linear sculpture. *Cyclestherioides franconica* (Reible, 1962, p. 217, fig. 18, pl. 9, fig. 6) from the Upper Triassic of Germany has approximately 30 distinct growth lines and densely spaced growth bands in large adults and should not be assigned to this genus. Tasch (1987) erected *Cyclestherioides* (*C.*) *alexandriae* from the Lower Jurassic of the Transantarctic Mountains (p. 69, pl. 12, figs. 1, 2; pl. 14, figs. 7, 8; pl. 18, fig. 6). It probably belongs to *Carapacestheria* Shen, 1994 in terms of shell configuration and thick valve. The placement of *Cyclestherioides* (*C.*) *pintoi* (Tasch, 1987, p. 114, pl. 34, fig. 3a, Middle Permian Estrada Nova Formation, Brazil) in this genus is also questionable, because it bears more than 30 dense growth bands. Assignment of *Cyclestherioides dalongkouensis* Liu, 1989 and *C. triangularis* Liu, 1989 from the

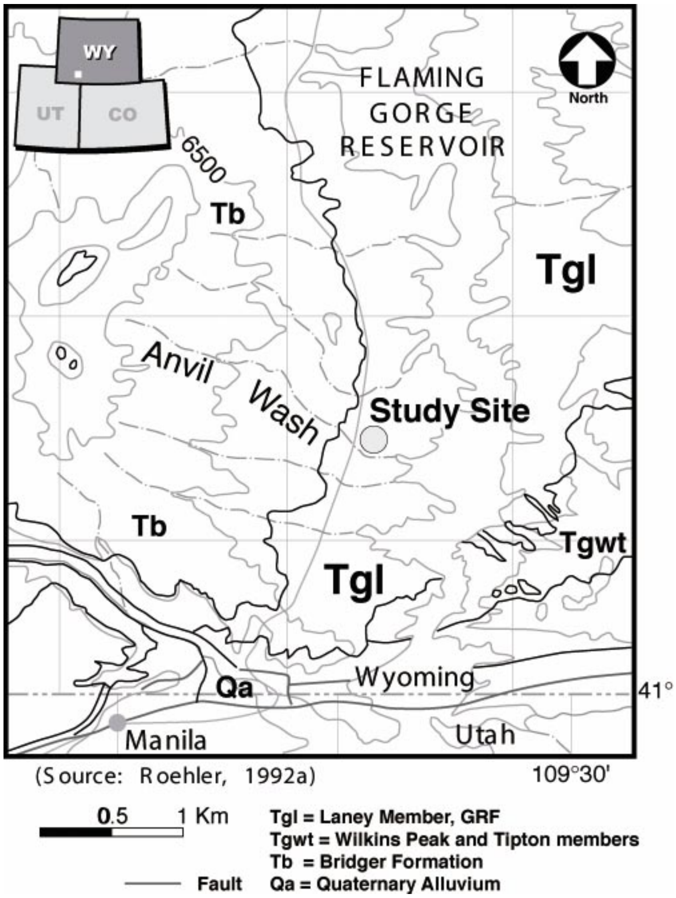


FIGURE *1*—Location map, showing study location and geology. The study site falls within the Laney Member (Tgl) of the Green River Formation, in the southern part of the Green River Basin, in the Eocene of the Rocky Mountain region (southwestern Wyoming, Utah, and Colorado).

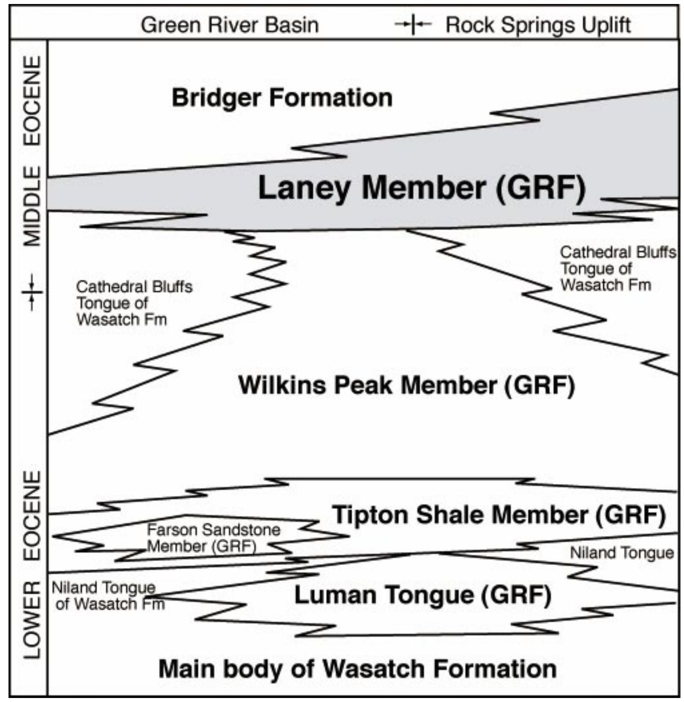


FIGURE *2*—Regional stratigraphic relationships. Rocks and fossils studied occur in the Eocene Laney Member of the Green River Formation (GRF), southwestern Wyoming (after Roehler, 1992).

Lower Triassic Dalongkou Formation of Xinjiang, China (p. 134, pl. 35, figs. 3, 4; p. 134, pl. 35, fig. 5), and *Cyclestheria rossica* Novojilov, 1959 from the Lower Triassic of Russia (*via* Molin and Novojilov, 1965, p. 61, pl. 8, fig. 2) to this genus are also questionable.

However, the following species may belong to the cyclestheriids: *Cyclestherioides detykteica* Novojilov *in* Molin and Novojilov, 1965 (p. 51, pl. 5, figs. 5, 6) from the Upper Permian Bugaliktin Formation, Tungus, Russia; *Cyclestherioides* (?*Cyclestherioides*) sp. from the ?Upper Permian Middle Member of the Peine Formation, northern Chile (Gallego and Breitkreuz, 1994, pl. 2, fig. 6); *Euestheria sparsa* Shen *in* Zhang et al., 1976 (pl. 19, figs. 2, 3) from the Middle Triassic (Anisian) Badong Formation, Hubei, China; and *Euestheria*? cf. *E. atsuensis* (Kobayashi, 1952 *in* Zhang et al., 1976, pl. 18, fig. 16) from the Upper Triassic (Norian) Xujiahe Formation, Sichuan, China. Cyclestheriids seem to range from Late Permian to Holocene, although they are absent from the fossil record in the middle and late Mesozoic.

Based on morphological and molecular data, cyclestherids differ significantly from other spinicaudate conchostracans and should not be placed among spinicaudates. It is transitional between spinicaudatans and cladocerans (Spears and Abele, 2000; Martin and Davis, 2001; Olesen, 2002). Ax (1999) first suggested the term ''Cladoceromopha'' for the clade containing *Cyclestheria* plus Cladocera. Martin and Davis (2001) recommended removal of *Cyclestheria* from the Spinicaudata. They placed it in a new suborder, the Cyclestherida. We follow this classification, but retain use of the order Conchostraca, which includes five suborders (Shen, 2003): Laevicaudata, Spinicaudata, Cyclestherida, Leaiida (Devonian to Permian), and Estheriellina (Triassic to Early Cretaceous).

CYCLESTHERIOIDES WYOMINGENSIS Shen and Gallego,
new species
Figure 4.1–4.9; Appendix 1

Diagnosis.—Carapace thin, subcircular to ovate, small to moderate, 7–10 weak growth lines, the second one more obvious than others, irregularly small reticulations on growth bands.

Description.—Carapace thin, subcircular to ovate, small to moderate, 2.9–5.6 mm long, 2.4–4.5 mm high, height to length ratio of 0.7:0.9; dorsal margin long, gently arched upwards, umbo slightly rising above dorsal margin and situated at subterminal to subcentral of dorsal margin; anterior and posterior margins rounded, ventral margin slightly curved downward; growth lines 7–10, weak, fine, the second one more obvious than others, those of the middle part of valve weakest; more or less equal width growth bands; ornamented with small irregular transverse reticulations.

Etymology.—From Wyoming.

Types.—Holotype, NIGPAS 134177 (Fig. 4.6). Paratypes NIGPAS 134166, 134168 (Fig. 4.1, 4.8); PZ-CTES N° 7340–7347. Over 183 individuals, among which 78 came from GR2 bed and 105 from GR3 bed. Most of the valves are complete or slightly displaced.

Occurrence.—The Eocene Laney Member of the Green River Formation, Anvil Wash section, Wyoming, USA.

Discussion.—The new species is distinguished from all other species assigned to this genus (Raymond, 1946; Molin and Novojilov, 1965; Zhang et al., 1976) by weak and fine growth lines in which the second one is more obvious than the others. It closely

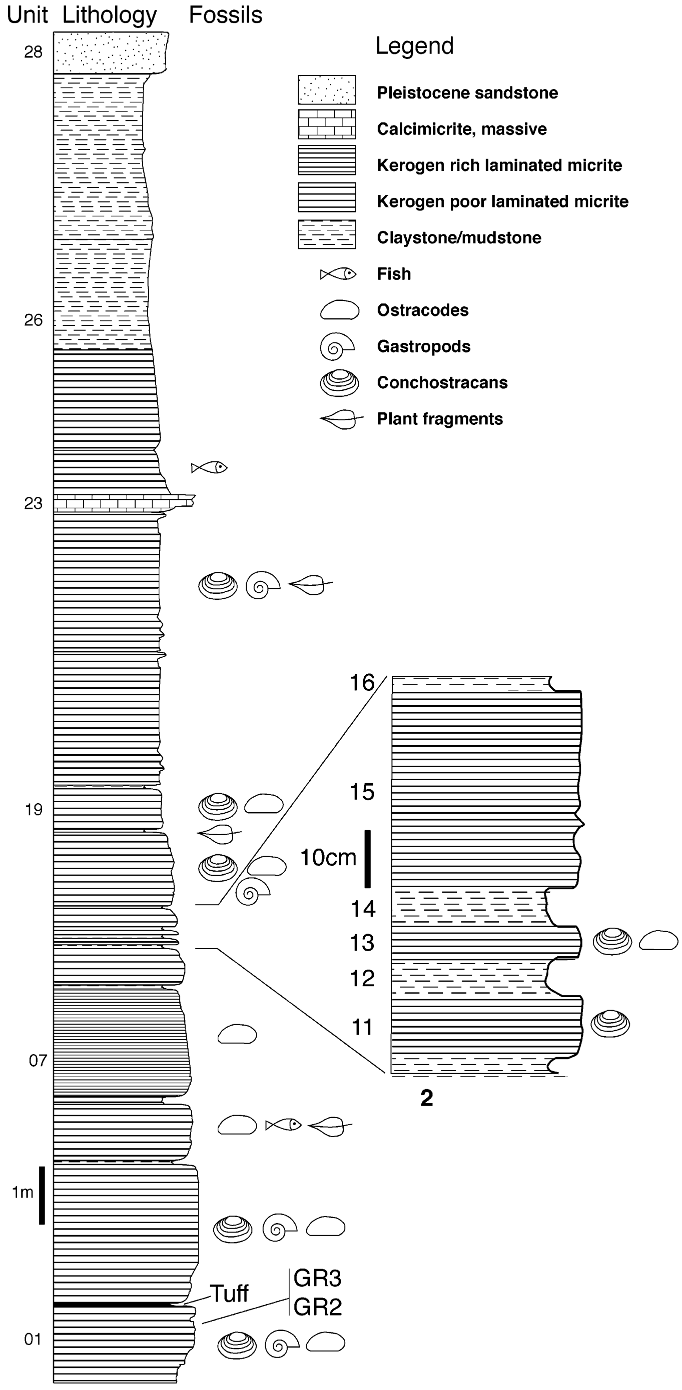


FIGURE 3—The Anvil Wash stratigraphic section. *1*, Measured stratigraphic section (scale bar = 1 m); *2*, expanded stratigraphy of units 10–16, kerogen-poor, laminated micrite (KPLM) alternates in cyclic fashion with claystone.

resembles extant *Cyclestheria hislopi* (Daday, 1926) in carapace configuration, the weak growth lines, and thin valve, but differs in that its second growth line is stronger than the others. *Paracyclestheria sinensis* (Shen and Dai, 1987) differs from the new species in its very weak growth lines.

Suborder LAEVICAUDATA Linder, 1945 (*via* Tasch, 1969)
Family LYNCEIDAE Stebbing, 1902
Genus PROLYNCEUS Shen and Chen, 1984
PROLYNCEUS LANEYENSIS Shen and Gallego, new species
Figure 4.10–4.16; Appendix 1

Diagnosis.—Subcircular to ovate, small, one peripheral growth line.

Description.—Carapace subcircular to ovate, small, 1.2–1.5 mm long, 1.05–1.1 mm high, height to length ratio of 0.72:0.88; dorsal margin long, slightly arched upward; anterior margin broadly curved, posterior margin rounded; ventral margin slightly curved downward; one peripheral growth line; sculpture unclear.

Etymology.—From the Laney Member of the Green River Formation.

Types.—Holotype NIGPAS 134181(Fig. 4.16); paratype NIGPAS 134184 (Fig. 4.11, 4.12), PZ-CTES N° 7348–7350. Twelve specimens, among which two came from bed GR2 and 10 came from bed GR3. All specimens are complete valves, but are not well preserved.

Occurrence.—As for *Cyclestherioides wyomingensis* n. sp.

Discussion.—Fossil lynceids include two genera: *Paleolynceus* Tasch, 1956 and *Prolynceus*. The former occurs in the Lower Cretaceous Usqi-Karl Formation of Transbaikal, Siberia (Tasch, 1956; Krasinetz, 1964). The latter occurs in the upper Middle Jurassic Tuchengzi Formation of Beipiao, Liaoning Province, China (Shen and Chen, 1984). As for shell configuration they are very similar to those of extant forms, but *Paleolynceus* bears a larger valve (reaching 14.4 mm long) (Krasinetz, 1964) than other fossil lynceids (usually 1.3–5 mm long) (Royan and Alfred, 1971; Saunders and Wu, 1984). *Prolynceus* has a peripheral growth line, vertically prolonged shell gland situated at the anteromedial part of the valve, and a telson that is similar to the extant lynceids (Shen and Chen, 1984).

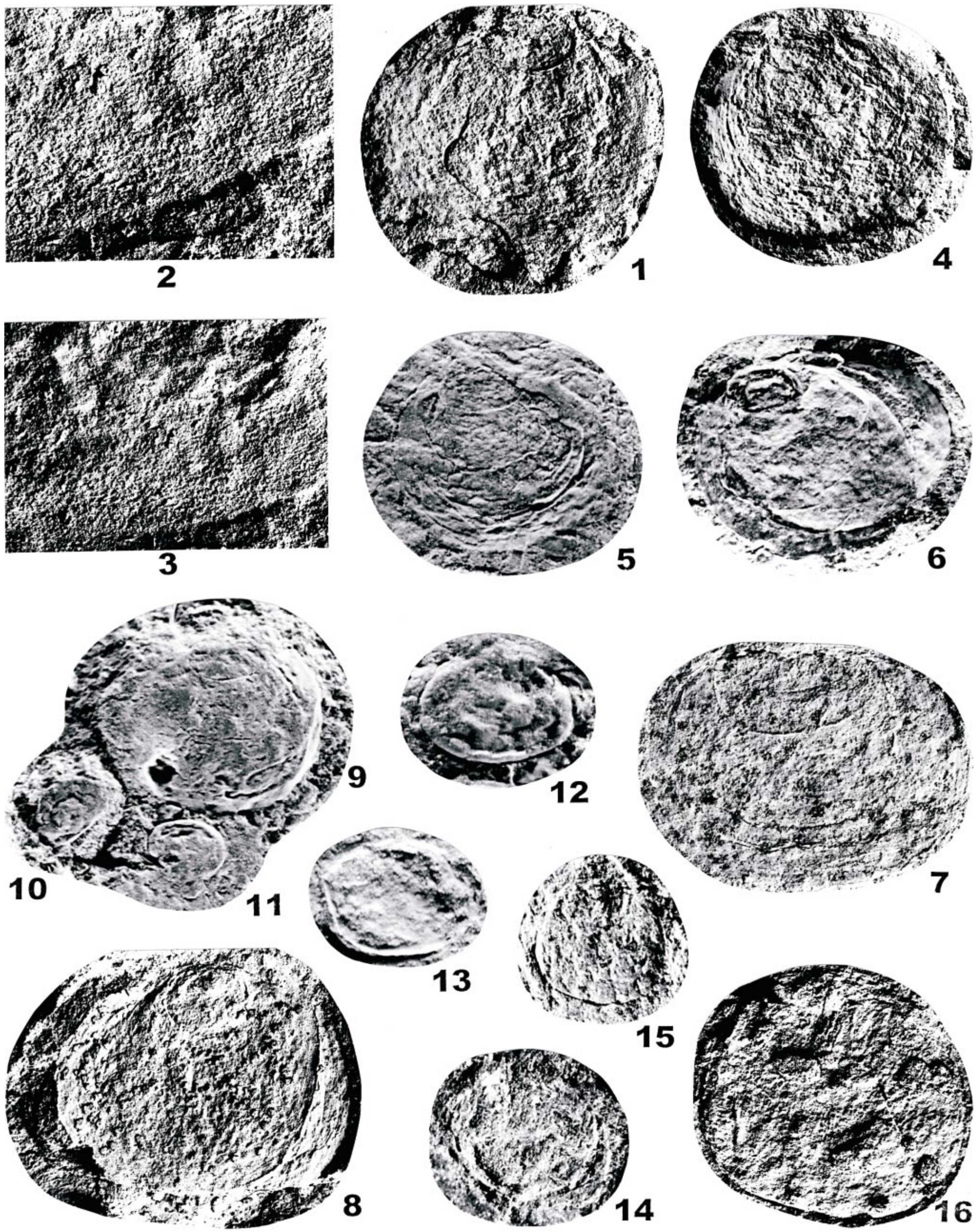
The new species is similar to *Prolynceus lineatus* (Shen and Chen, 1984, p. 315, pl. 1, figs. 6, 7) in having a peripheral growth line, although the appendages are not found from available collections. *P. laneyensis* differs from *P. lineatus* in its oval configuration and much smaller valve. *Prolynceus laneyensis* is distinguished from most modern species of *Lynceus* by the presence of a peripheral growth line.

PALEOENVIRONMENTAL IMPLICATIONS

Extant conchostracans can be found on all continents except Antarctica, and although some species inhabit permanent bodies of water, most can be found in ephemeral pools or temporary

→

FIGURE 4—Magnification, *1*, *4–6*, *8–11*, ×10; others as indicated. *1–9*, *Cyclestherioides wyomingensis* Shen and Gallego, n. sp. *1*, Paratype, right valve, scanning photo, GR3–2, NIGPAS 134166; *2*, *3*, irregular and small reticulations on the growth bands of Figure 1, ×40, ×60, scanning photo; *4*, internal mold of the left valve, scanning photo, GR3–8, NIGPAS 134171; *5*, external mold of the right valve, scanning photo, GR3–21, NIGPAS 134180; *6*, holotype, external mold of the displaced right and left valve, GR3–15, NIGPAS 134177; *7*, external mold of the right valve, ×15.3, scanning photo, GR3–1, NIGPAS 134165; *8*, paratype, external mold of the left valve, scanning photo, GR3–4, NIGPAS 134168; *9*, internal mold of the right valve, GR3–17, NIGPAS 134179. *10–16*, *Prolynceus laneyensis* Shen and Gallego, n. sp. *10*, Internal mold of the right valve, GR3–20, NIGPAS 134186; *11*, *12*, paratype, internal mold of the right valve, ×20 (*12*), GR3–18, NIGPAS 134184; *13*, external mold of the right valve, ×20, GR3–19, NIGPAS 134185; *14*, internal mold of the right valve, ×20, GR3–4c, NIGPAS 134182; *15*, internal mold of the right valve, ×20, GR3–7, NIGPAS 134183; *16*, holotype, internal mold of the right valve, ×40, scanning photo, GR3–4b, NIGPAS 134181.


2
1
4
3
5
6
9
12
7
10
11
13
15
8
14
16

waters (Frank, 1988). They generally live in small, temporary or permanent inland ponds, floodplain pools, roadside ditches, rice paddy fields, margins of big lakes, estuaries, lagoons, and even inundated road ruts (Tasch, 1969; Chen and Shen, 1985). Most fossil conchostracans are believed to have lived in freshwater pools. Although some species can tolerate either high salinity or brackish water, they have never been found in full marine environments.

The extant *Lynceus* is basically benthic, mostly resting on the bottom but often swimming freely and slowly for short periods. It is probably omnivorous (Fryer, 1987) and is widely distributed in the world. In Europe, findings reach northwards to Scandinavia (~70°N) (Straškraba, 1965). *Lynceus brachyurus* Müller, 1776 *in* Straškraba, 1965 (p. 208) is present from about 9°E throughout Europe and Siberia to East Asia, and northwards as far as the arctic zone (Brtek and Thiéry, 1995). This species is eurytopic, living in ditches, temporary pools, and inundated fields. *Lynceus manchuricus* Daday, 1913 was found in a temporary pond in Inner Mongolia, China, associated with the notostracans (Uéno, 1940). *Lynceus taianensis* (Han and Shu, 1995) was collected from a stew in Taian, Shandong Province. In northern America, lynceids were found in a shallow (<1.0 m) ephemeral pond in Leon County, Florida, where the water temperature was 24°C and air temperature 25°C on 9 April 1984. Water in the pond also contained aquatic insects, frog tadpoles, and large anostracans (Martin et al., 1986). In South America, lynceids extend across from Venezuela, through Brazil, and then to southern Argentina (Crespo, 1993).

Cyclestheriidae includes two modern genera, *Cyclestheria* and *Paracyclestheria* (Shen and Dai, 1987), and the fossil genus *Cyclestherioides*. *Cyclestheria*, consisting of only one species (*C. hislopi*), occurs in India, Southeast Asia, southern China, Africa, South America, Central America, and Australia (Daday, 1926; Tasch, 1969; Halloy, 1981; Poi de Neiff and Bruquetas, 1983; Shen and Dai, 1987; Olesen et al., 1997). *Paracyclestheria* was found in Yunnan, China.

Cyclestheria hislopi is a pantropical species found between approximately 30°N and 35°S (Olesen et al., 1997). In Argentina, this species was collected from a flood zone in Paraná River Basin, where a fluvial lowland with abundant marshy and aquatic vegetation is located. This species was found between the roots of the water hyacinth *Eichhornia crassipes* (Martius) Solms-Laubach, 1883. Environmental data are conductivity 56–58 uS/cm, transparency 28 cm, and surface temperature 27.9°C (Halloy, 1981), recorded from an oxbow lake on the northern reaches of the Paraná River Valley. The limnological characteristics were: depth 3.4 m, pH between 7.0 and 7.4, conductivity 90 and 170 uS/cm, with no substantial dissolved oxygen variations (0.75–1.0 mg/l) (Poi de Neiff and Bruquetas, 1983). Poi de Neiff (2003) found *C. hislopi* living on *Eichhornia azurea* (Swartz) Kunth, 1842 along the Paraguay River floodplain. In Pantanal of southern Brazil the species is extremely frequent during the dry season (low-water period) (Por and Rocha, 1998). In India, this species was found in paddy fields of the Punjab, and ponds and small ditches near Ludhiana (Battish, 1981). *Paracyclestheria sinensis* was found in a pond (22°N, 101°E) in Xishuangbanna, Yunnan Province, China, with the following environmental data: elevation crassipes 860 m a.s.l., depth 0.2–0.4 m, pH 6, and surface temperature 20.5°C on 17 March 1957 (Shen and Dai, 1987).

The occurrence of the fossil pulmonate gastropod *Biomphalaria aequalis* White, 1880, along with these conchostracans, is paleoecologically very revealing. *Biomphalaria* sp. is typical of the Eocene of the Rocky Mountains but disappears from the region after this time. The extant *B. glabrata* Say, 1818, a modern-day equivalent, living in quiet, shallow, mud-bottomed ponds, but can survive desiccation in seasonal water bodies. It is found in the American tropics, and from laboratory experiments it is known that its optimum temperature for oviposition is 25°C (Taylor, 1988).

Therefore, *Cyclestherioides*, with the pulmonate gastropod in the Laney Member, indicates a subtropical setting. This substantiates the findings derived from the occurrence of warm temperate and subtropical macro- and microfloras, suggesting that the region received ample rainfall, perhaps seasonally, and that temperatures were relatively mild.

ACKNOWLEDGMENTS

This study was supported by the National Natural Science Foundation of China (Grant 40072002) and the State Key Laboratory of Palaeobiology and Stratigraphy (Grant 023101) to SYB. We thank F. R. Schram for his valuable comments on the manuscript. Thanks to Yuan Liuping and Chen Zhouqing for the photography. OFG thanks G. Lavia (from the SEM staff-SECyT–UNNE, now at IBONE–CONICET–UNNE) for her assistance, R. Z. Rodríguez (FACENA—UNNE) for photographic assistance, and A. Poi de Neiff (CECOAL–CONICET, Corrientes–Argentina) for providing important data and comments on the ecology of *Cyclestheria hislopi* from Paraná and the Paraguay River. Thanks also to the Consejo Nacional de Investigaciones Científica y Técnicas (CONICET–Argentina) for the postdoctoral fellowship to OFG, and to the Universidad Nacional del Nordeste for research support. L. E. Babcock and A. L. Rode reviewed the manuscript and provided important comments to improve the paper.

REFERENCES

AX, P. 1999. Phyllopodomorpha, p. 156–168. *In* Das System der Metazoa II. Ein Lehrbuch der phylogenetischen Systematik. G. Fischer, Mainz.

BARNARD, K. H. 1929. Contributions to Crustacean fauna of South Africa. No. 10. A revision of the South African Branchiopoda (Phyllopoda). South African Museum Annual, 29:181–272.

BATTISH, S. K. 1981. On some conchostracans from Punjab with the description of three new species and a new subspecies. Crustaceana, 40(2):178–196.

BIAGGI, R. E. 2001. Paleoecology, taphonomy and paleoenvironments of a unique littoral ecosystem within the Eocene Green River Formation of Wyoming. Unpublished doctoral dissertation, Loma Linda University, California, 106 p.

BRTEK, J., AND A. THIÉRY. 1995. The geographical distribution of the European branchiopods (Anostraca, Notostraca, Spinicaudata, Laevicaudata). Hydrobiologia, 298:263–280.

BUCHHEIM, H. P. 1978. Paleolimnology of the Laney Member of the Eocene Green River Formation. Ph.D. dissertation, University of Wyoming, Laramie, 101 p.

BUCHHEIM, H. P., AND R. SURDAM. 1981. Paleoenvironments and fossil fishes of the Laney Member, Green River Formation, Wyoming, p. 415–452. *In* J. Gray et al. (eds.), Communities of the Past. Hutchinson Ross, Stroudsburg, Pennsylvania.

CHEN, P. J. 1975. Tertiary Conchostraca from China. Scientia Sinica, 6: 618–630.

CHEN, P. J., AND SHEN YAN-BIN. 1979. Mesozoic and Cenozoic conchostracan faunas of China, with notes on their distributions in the red beds of South China, p. 295–299. *In* Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences and Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences (eds.), Mesozoic and Cenozoic Red Beds of South China. Science Press, Beijing. (In Chinese with English abstract)

CHEN, P. J., AND SHEN YAN-BIN. 1980. On the *Paraleptestheria menglaensis* fauna with reference to the age of the Lofochai Group. Acta Palaeontologica Sinica, 19(3):182–189. (In Chinese with English abstract)

CHEN, P. J., AND SHEN YAN-BIN. 1981. Paleogene conchostracans faunas of China. Geological Society of America Special Paper, 187:193–198.

CHEN, P. J., AND SHEN YAN-BIN. 1985. An Introduction to Fossil Conchostraca. Science Press, Beijing, 241 p. (In Chinese)

CRESPO, F. A. 1993. A new record of the family Lynceidae Stebbing, 1902 (Branchiopoda, Conchostraca) from Argentina. Physis, Secc. B, 51(120–121):21–22.

DADAY, DE DEES. 1913. Deux aberrations intéressantes dans le sous-ordre Phyllopoda Conchostraca. Annales des Sciences Naturelles, Zoologie, serie 9, 17:195–206.

DADAY, DE DEES. 1926. Monographie systématique des phyllopodes conchostracés. Annales des Sciences Naturelles Zoologie, 9:578–585.

DEPÉRET, C., AND P. MAZERAN. 1912. Les *Euestheria* du Permien d'Autun. Société d'Histoire Naturelle d'Autun Bulletin, 25:165–173.

FRANK, P. W. 1988. Conchostraca. Palaeogeography, Palaeoclimatology, Palaeoecology, 62:399–403.

FRYER, G. 1987. A new classification of the branchiopod, Crustacea. Zoological Journal of the Linnean Society, 91:357–383.

GALLEGO, O. F., AND C. BREITKREUZ. 1994. Conchostracos (Crustaceae–Conchostraca) paleozoicos de la Región de Antofagasta, norte de Chile. Rivista Geologica de Chile, 21(1):31–53.

GALLEGO, O. F., AND M. V. MESQUITA. 2000. First record of Oligocene conchostracan (Tremenbé Formation, Taubaté Basin) from Sãopaulo, São Paulo Brazil. Journal of South American Earth Sciences, 13:685–692.

GRANDE, L. 1984. Paleontology of the Green River Formation with a review of the fish fauna. Bulletin of the Geological Survey of Wyoming, 63:236–239.

HALLOY, S. 1981. Notas sobre *Cyclestheria hislopi* (Baird) (Crustacea, Conchostraca) encontrada en Argentina. Acta Zoológica Lilloana, 36(2):5–9.

HAN, M. S., AND SHU YUN-FANG. 1995. Atlas of Freshwater Biota in China. China Ocean Press, Beijing, 375 p. (In Chinese with English abstract)

HONG, Y. C., YANG ZHU-CHIANG, WANG SHI-TAO, WANG SI-EN, LI YU-KUEI, SUN MEN-RUNG, SUN HSIANG-CHUN, AND TU NAI-CHIU. 1974. Stratigraphy and paleontology of Fushun coal-field, Liaoning Province. Geologica Sinica, 2:113–149. (In Chinese with English abstract)

KOBAYASHI, T. 1952. Two new Triassic estherians from province of Nagato in West Japan. Transactions and Proceedings of the Palaeontological Society of Japan, n. s., 6:175–178.

KRASINETZ, C. C. 1964. New Lynceidae (Conchostraca, Crustacea) from Lower Cretaceous, eastern Probaikal. Geology and Geophysics, 9:115–120. (In Russian)

KUNTH, E. 1842. Repertorium Botanices Systematicae, 1(4):129.

LINDER, F. 1945. Affinities within the Branchiopoda, with notes on some dubious fossils. Arkiv för Zoologi, Stockholm, 37(A)(4):1–28.

LIU, S. W. 1989. Conchostraca, p. 123–139. *In* Institute of Geology and Mineral, Xinjiang Bureau of Geology and Mineral Resources, and Institute of Geology, Chinese Academy of Geological Sciences (eds.), Research on the Boundary Between Permian and Triassic in Tianshan Mountain of China. China Ocean Press, Beijing. (In Chinese with English abstract)

MACHLUS, M., S. R. HEMMING, P. E. OLSEN, AND N. CHRISTIE-BLICK. 2002. 40Ar/39Ar ages of selected tuffs of the Green River Formation: Implications for interbasin and intrabasin correlation. Geological Society of America, Abstracts with Programs, 34(6):558.

MARTIN, J. W., AND G. E. DAVIS. 2001. An updated classification of the recent Crustacea. Natural History Museum of Los Angeles County Science Series, 39:1–124.

MARTIN, J. W., B. E. FELGENHAUER, AND L. G. ABELE. 1986. Redescription of the clam shrimp *Lynceus gracilicornis* (Packard) (Branchiopoda, Conchostraca, Lynceidae) from Florida, with notes on its biology. Zoologica Scripta, 15(3):221–232.

MCGREW, P. O. 1959. The geology and paleontology of the Elk Mountain and Tabernacle Butte Area, Wyoming. American Museum of Natural History Bulletin, 117(3):121–176.

MOLIN, B. A., AND N. I. NOVOJILOV. 1965. Permian and Triassic Conchostracans from North Russia. Science Press, Leningrad, 117 p. (In Russian)

MÜLLER, O. F. 1776. Zoologiae Danicae Prodromus, seu Animalium Daniae et Norvegiae Indigenarum Characteres, Nomina, et Synonyma Imprimis Popularium. Havniae. Zoologiae Danicae Prodromus, xxxii + 282 p.

NOVOJILOV, N. I. 1954. Crustaces Phyllopodes du Jurassique superieur et du Cretaces de Mongolie. Travaux lnstitut Paleontologique Academic des Sciences de I'URSS, 48:7–124.

NOVOJILOV, N. I. 1958. Recueil d'articles sur les phyllopodes Conchostracés. Annales du Service d'Information Géologique du Bureau de Recherches Géologiques Géophysiques et Minières, Paris, 26:1–135.

NOVOJILOV, N. I. 1959. New Permian and Triassic conchostracans from Belarus, Baltic and Yakut. Materials of Essential Palaeontology, 3:1–29. (In Russian)

NOVOJILOV, N. I. 1960. Subclass Gnathostraca. p. 220–252. *In* Yu. A. Orlov (ed.), Basic Paleontology, 8. (In Russian)

OLESEN, J. 2002. Branchiopod phylogeny—continued morphological support for higher taxa like the Diplostraca and Cladocera, and for paraphyly of 'Conchostraca' and 'Spinicaudata.' Crustaceana, 75:77–84.

OLESEN, J., J. W. MARTIN, AND E. W. ROESSLER. 1997. External morphology of the male of *Cyclestheria hislopi* (Baird, 1859) (Crustacea, Branchiopoda, Spinicaudata), with a comparison of male claspers among the Conchostraca and Cladocera and its bearing on phylogeny of the 'bivalved' Branchiopoda. Zoologica Scripta, 25(4):291–316.

PETRULEVICIUS, J. F. 2001. Insectos del Paleógeno del Noroeste de la Argentina. Sistemática, tafonomía y paleosinecología. Tesis Doctoral, Universidad Nacional de La Plata, Argentina, 229 p.

POI DE NEIFF, A. 2003. Macroinvertebrates living on *Eichhornia azurea* Kunth in the Paraguay River. Acta Limnologica Brasileira, 15(1):55–63.

POI DE NEIFF, A., AND I. BRUQUETAS. 1983. Fauna fitófila de *Eichhornia* en ambientes leníticos afectados por las crecidas del Río Paraná. Ecosur, 10(19–20):121–137.

POR, E. D., AND C. E. ROCHA. 1998. The *Pleustal*, a third limnic biochore and its neotropical centre. Verhandlungen der Internationale Vereinigung für Theoretische und Angewandte Limnologie, 26:1876–1881.

RAYMOND, P. E. 1946. The genera of fossil Conchostraca—an order of bivalved Crustacea. Bulletin of Museum Comparative Zoology at Harvard College, 96(3):217–307.

REIBLE, P. 1962. Die Conchostraken (Branchiopoda, Crustacea) der Germanyschen Trias. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, Stuttgart, 114(2):169–244.

RICHTER, G., AND S. BASZIO. 2001. Trace of a liminic food web in the Eocene Lake Messel—a preliminary report based on fish coprolite analyses. Palaeogography, Palaeoclimatology, Palaeoecology, 166:345–368.

ROEHLER, H. W. 1973. Stratigraphic divisions and geologic history of the Laney Member of the Green River Formation in the Washakie Basin in southwestern Wyoming. USGS Bulletin, 1372-E:1–28.

ROEHLER, H. W. 1992. Correlation, composition, areal distribution, and thickness of Eocene stratigraphic units, Greater Green River Basin, Wyoming, Utah, and Colorado. USGS Professional Paper, 1506-E:1–49.

ROYAN, J. P., AND J. R. B. ALFRED. 1971. *Lynceus serratus* sp. nov. (Conchostraca, Lynceidae) from southern India. Crustaceana, 21(1):37–40.

SARS, G. O. 1867. Histoire Naturelle des Crustaces d'eau Douce Norvege. Premiere livraison. Les Malacostraces Christiania, p. 1–145.

SARS, G. O. 1887. On *Cyclestheria hislopi* (Baird) a new generic type of bivalve phyllopoda, raised from dried Australian mud. Forhandlinger i Videnskabsselskabet i Kristiania, 1:223–239.

SARS, G. O. 1899. On some Indian Phyllopoda. Archiv for Mathematik og Naturvidenskab, 22(9):3–30.

SAUNDERS, J. F., AND WU SHI-KUEI. 1984. Eubranchiopoda of Colorado, Pt. 3, Conchostraca. Natural History Inventory of Colorado, No. 8:1–19.

SAY, T. 1818. Account of two new genera, and several new species, of fresh water and land shells. Journal of Academic Nature Science Philadelphia, 1:276–284.

SHEN, C. J., AND DAI AI-YUN. 1987. A new and rare species of Conchostraca from Yunnan Province, China (Crustacea: Conchostraca). Acta Zootaxonomica Sinica, 12(4):353–356. (In Chinese with English abstract)

SHEN, Y. B. 1994. Jurassic conchostracans from Carapace Nunatak, South Victoria Land, Antarctica. Antarctic Science, 6(1):105–113.

SHEN, Y. B. 2003. Review of the classification of the family Aftrograptidae (Crustacea: Conchostraca). Acta Palaeontologica Sinica, 42(4): 590–597. (In Chinese with English abstract)

SHEN, Y. B., AND CHEN PEI-JI. 1979. A discovery of the Early Tertiary conchostracans near the Gulf of Hangzhou. p. 295–299. *In* Institute of

Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences and Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences (eds.), Mesozoic and Cenozoic Red Beds of South China. Science Press, Beijing. (In Chinese)

SHEN, Y. B., AND CHEN PEI-JI. 1984. Late Middle Jurassic conchostracans from the Tuchengzi Formation of W. Liaoning, NE China. Bulletin of Nanjing Institute of Geology and Palaeontology, Academia Sinica, 9: 309–326. (In Chinese with English abstract)

SHEN, Y. B., AND ZHANG XIANG-QIU. 1979. Early Tertiary conchostracans from Sanshui basin of Guangdong, p. 300–304. *In* Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences and Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences (eds.), Mesozoic and Cenozoic Red Beds of South China. Science Press, Beijing. (In Chinese)

SOLMS-LAUBACH, H. G. 1883. Alphonse Louis Pyramus De Candolle. Monographiae phanerogamerum, 4:1–527.

SPEARS, T., AND L. G. ABELE. 2000. Branchiopod monophyly and interordinal phylogeny inferred from 18S ribosomal DNA. Journal of Crustacean Biology, 20:1–24.

STEBBING, T. R. R. 1902. *Lynceus* and the Lynceidae. Zoologist, 6:101–106.

STRAŠKRABA, M. 1965. Taxonomic studies on Czechoslovak Conchostraca, II, families Lynceidae and Cyzicidae. Acta Societatis Zoologicae Bohemoslovenicae, 29(3):205–214.

TASCH, P. 1956. Three general principles for a system of the classification of fossil conchostracans. Journal of Paleontology, 30(5):1248–1257.

TASCH, P. 1969. Branchiopoda, p. R141–163. *In* R. C. Moore (ed.), Treatise on Invertebrate Paleontology. Pt. R. Arthropoda: Conchostraca. Geological Society of America and University of Kansas Press, Lawrence.

TASCH, P. 1987. Fossil Conchostraca of the Southern Hemisphere and continental drift. Geological Society of America Memoir, 165:1–290.

TAYLOR, D. W. 1988. Aspects of freshwater mollusc ecological biogeography. Palaeogeography, Palaeoclimatology, Palaeoecology, 62:511–576.

TRUSSOVA, E. K., AND D. BADAMGARAV. 1976. O pervoy nakhodke Actakaynozoyskikh dvustvorchatykh listonogikh rakoobraznyh (Conchostraca), p. 162–168. *In* N. N. Kramarenko (ed.), Paleontologiya i biostratigrafiya Mongolii, Sovmestnaya Sovetsko-Mongolskaya Plaeontologicheskaya Ekspeditsiya, Trudy, 3. (In Russian)

UÉNO, M. 1940. Phyllopod Crustacea of Manchoukuo. Bulletin Biogeographical Society of Japan, 10(5):87–102.

WHITE, C. A. 1880. Descriptions of new invertebrate fossils from the Mesozoic and Cenozoic rocks of Arkansas, Wyoming, Colorado, and Utah. U.S. Natural Museum Proceedings, 3:157–162.

ZHANG, W. T., CHEN PEI-JI, AND SHEN YAN-BIN. 1976. Fossil Conchostraca of China. Science Press, Beijing, 325 p. (In Chinese)

ACCEPTED 26 APRIL 2005

APPENDIX *1*—Qualitative and Quantitative data.

Specimens	Configuration	Preservation status	L(mm)	H(mm)	H/L	Gl	Notes
Cyclestherioides wyomingensis n. sp.							
NIGPAS 134165	subcircular	ext.m.right valve	4.0	2.8	0.70	8	
NIGPAS 134166	circular	right valve	4.9	4.1	0.84	?	paratype
NIGPAS 134167	circular	int.m.left valve	4.7	4.2	0.89	?	
NIGPAS 134168	circular	displaced valve	4.8	4.1	0.84	c.7	paratype
NIGPAS 134169	circular	displaced valve	3.7	3.2	0.86	?	
NIGPAS 134170	subcircular	right valve	5.6	4.5	0.8	c.10	
NIGPAS 134171	circular	int.m.left valve	4.4	3.9	0.89	c.9	
NIGPAS 134172	circular	left valve	2.9	2.6	0.90	c.9	
NIGPAS 134173	circular	left valve	4.1	3.5	0.85	>6	
NIGPAS 134174	subcircular	right valve	3.3	2.6	0.78	?	
NIGPAS 134175	circular	left valve	3.2	2.7	0.84	?	
NIGPAS 134176	circular	right valve	2.9	2.4	0.83	7	
NIGPAS 134177	ovate	ext.m.displaced valve	4.1	3.6	0.88	c.7	holotype
NIGPAS 134178	circular	displaced valve	4.8	?	?	c.7	
NIGPAS 134179	circular	int.m.right valve	3.8	3.2	0.84	7	
NIGPAS 134180	circular	ext.m.right valve	4.1	3.5	0.85	c.8	
Prolynceus laneyensis n. sp.							
NIGPAS 134181	subcircular	ext.m.left valve	1.2	1.1	0.88	1	holotype
NIGPAS 134182	subcircular	int.m.right valve	1.5	1.2	0.83	1	
NIGPAS 134183	subcircular	int.m.right valve	1.3	1.1	0.88	1	
NIGPAS 134184	ovate	int.m.right valve	1.5	1.1	0.73	1	paratype
NIGPAS 134185	ovate	ext.m.right valve	1.5	1.1	0.72	1	
NIGPAS 134186	ovate	int.m.right valve	1.5	1.0	0.69	1	

L = length of the valve; H = height of the valve; Gl = number of growth lines; ext.m = external mold; int.m = internal mold; ? = not clear.