**File S1**

**STEP COUNTS**

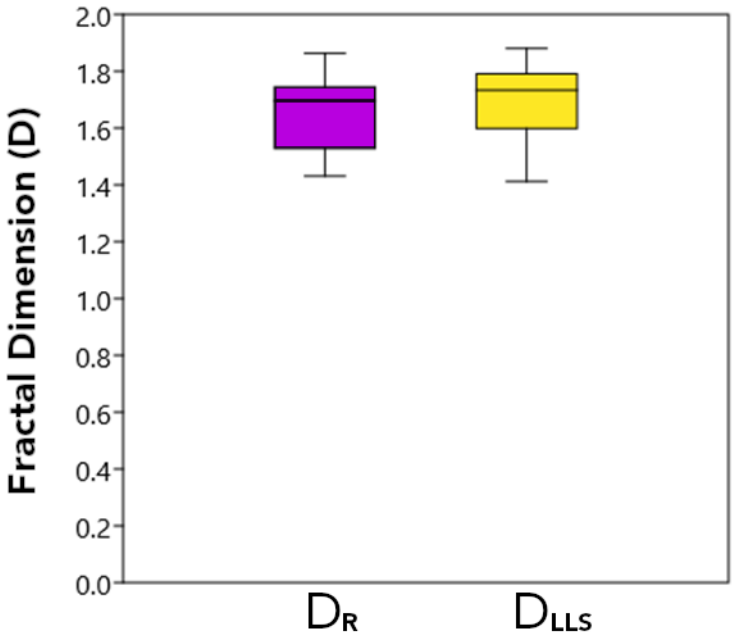
| | | | |
|---|---|---|---|
| Top row = Hemisuture (D) | 1/5 | 1/10 | 1/15 |
| Bottom Row = LLS (D) | 1/5 | 1/10 | 1/15 |

**FRACTAL DIMENSIONS (RIGHT COLUMN)**

| $D_R$ | $D_{LLS}$ |
|---|---|
| 1/10 | 1/10 |
| 1/5 | 1/5 |
| 1/15 | 1/15 (if applicable) |

Box-and-whisker plots show difference between medians and range of data.

| ***LYTOCERAS** STEP COUNTS (Conversion Value = 1.75)** | | | | **$D_R$** | **$D_{LLS}$** |
|---|---|---|---|---|---|
| *Lytoceras subsequens* | 14 | 47 | 98 | 1.640 | 1.745 |
| | 29 | 79 | 144 | 1.672 | 1.654 |
| | | | | 1.693 | 1.629 |
| *Megalytoceras submetrerum* | 15 | 57 | 105 | 1.683 | 1.861 |
| | 34 | 102 | 181 | 1.756 | 1.748 |
| | | | | 1.719 | 1.713 |
| *Eulytoceras phestum* | 20 | 73 | 139 | 1.861 | 1.825 |
| | 34 | 98 | 185 | 1.863 | 1.748 |
| | | | | 1.822 | 1.721 |
| *Lytoceras fraasi* | 16 | 53 | 99 | 1.723 | 1.824 |
| | 33 | 95 | 172 | 1.724 | 1.734 |
| | | | | 1.697 | 1.694 |
| *Lytoceras trilobeti* | 16 | 51 | 90 | 1.723 | 1.880 |
| | 33 | 89 | 154 | 1.707 | 1.706 |
| | | | | 1.662 | 1.701 |
| *Lytoceras exoticum* | 16 | 62 | 115 | 1.723 | 1.843 |
| | 34 | 102 | 177 | 1.792 | 1.766 |
| | | | | 1.752 | 1.705 |
| *Lytoceras serorugatum* | 10 | 30 | -- | 1.431 | 1.544 |
| | 21 | 57 | -- | 1.477 | 1.513 |
| Lytoceras julietti | 10 | 30 | -- | 1.431 | 1.375 |
| | 16 | 43 | -- | 1.477 | 1.390 |
| *Lytoceras alamadense* | 11 | 31 | -- | 1.490 | 1.375 |
| | 16 | 43 | -- | 1.491 | 1.390 |



**Sources for *Lytoceras***

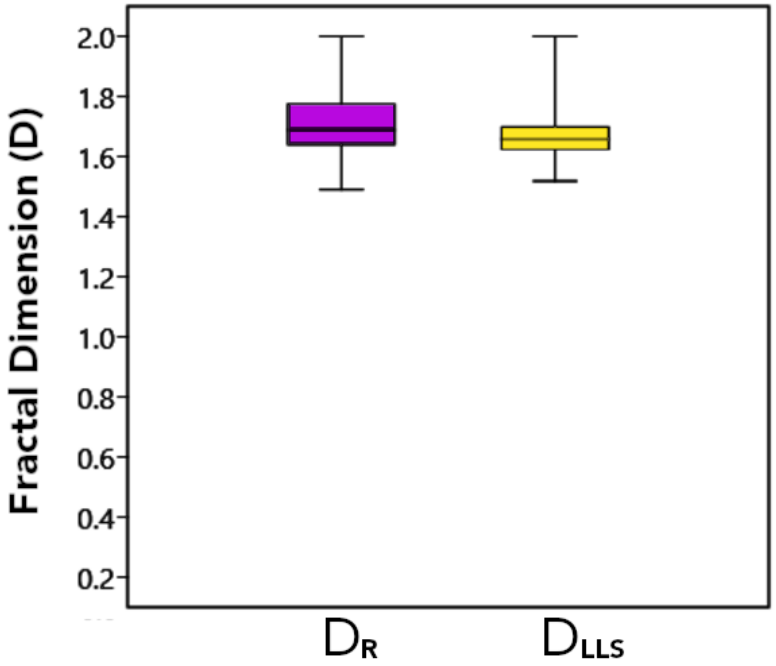
Hoffmann, R., 2010: New insights on the phylogeny of the Lytoceratoidea (ammonitina) from the septal lobe and its functional interpretation. Revue de Paleobiologie, 29(1). *Figure 14A, Figure 16B, Figure 17E Figure 24E, Figure 28C*

Schindewolf, O., 1968: Studien zur Stammesgeschichte der Ammoniten. Ash Akad Wiss Lit Mainz, Math-Nat, Kl, 13, 139-238, Lief 3. *Abb. 422, Abb. 16, Abb. 17.*

Hammer, Ø., Harper, D.A.T., and P. D. Ryan, 2001: PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica, 4(1).

Proceedings of the California Academy of Sciences Ser.3 Volume 1, Geology, *Plate 17.*

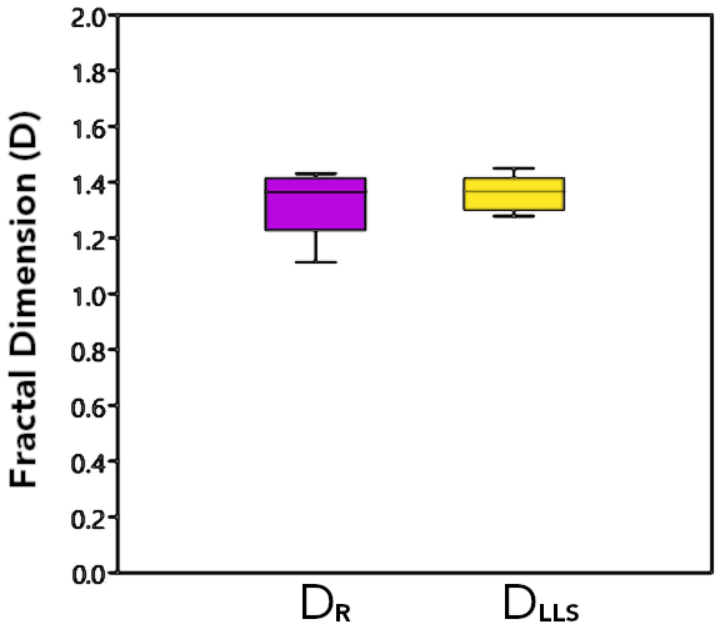
| ***GAUDRYCERAS/TETRAGONITES**** **STEP COUNTS (Conversion Value = 2)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Adnethiceras ferstli* | 20 | 53 | 99 | 1.861 | 1.906 |
| | 43 | 96 | 176 | 1.724 | 1.681 |
| | | | | 1.697 | 1.653 |
| *Zaghouanites* | 14 | 39 | 75 | 1.640 | 1.683 |
| | 30 | 85 | -- | 1.591 | 1.628 |
| *Peltolytoceras* | 11 | 35 | -- | 1.490 | 1.544 |
| | 23 | 78 | -- | 1.517 | 1.591 |
| *Kossmatella* | 14 | 47 | 98 | 1.640 | 1.662 |
| | 29 | 79 | 144 | 1.672 | 1.597 |
| | | | | 1.693 | 1.579 |
| *Ectocentrites petersi* | 25 | 81 | 147 | 2.000 | 2.000 |
| | 50 | 146 | 252 | 1.908 | 1.863 |
| | | | | 1.843 | 1.786 |
| *Eogaudryceras numidum* | 15 | 47 | 90 | 1.683 | 1.683 |
| | 30 | 90 | 180 | 1.672 | 1.653 |
| | | | | 1.662 | 1.662 |
| *Anagaudryceras sp.* | 17 | 60 | -- | 1.760 | 1.703 |
| | 31 | 85 | -- | 1.778 | 1.628 |
| *Zelandites kaiparaensis* | 16 | 42 | -- | 1.723 | 1.640 |
| | 28 | 84 | -- | 1.623 | 1.623 |



Hoffmann, R., 2010: New insights on the phylogeny of the Lytoceratoidea (ammonitina) from the septal lobe and its functional interpretation. Revue de Paleobiologie, 29(1). Figure 2D, Figure 5A, Figure 18D, Figure 31E, Figure 32C, Figure 44D, Figure 54A

Hammer, Ø., Harper, D.A.T., and P. D. Ryan, 2001: PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica, 4(1).

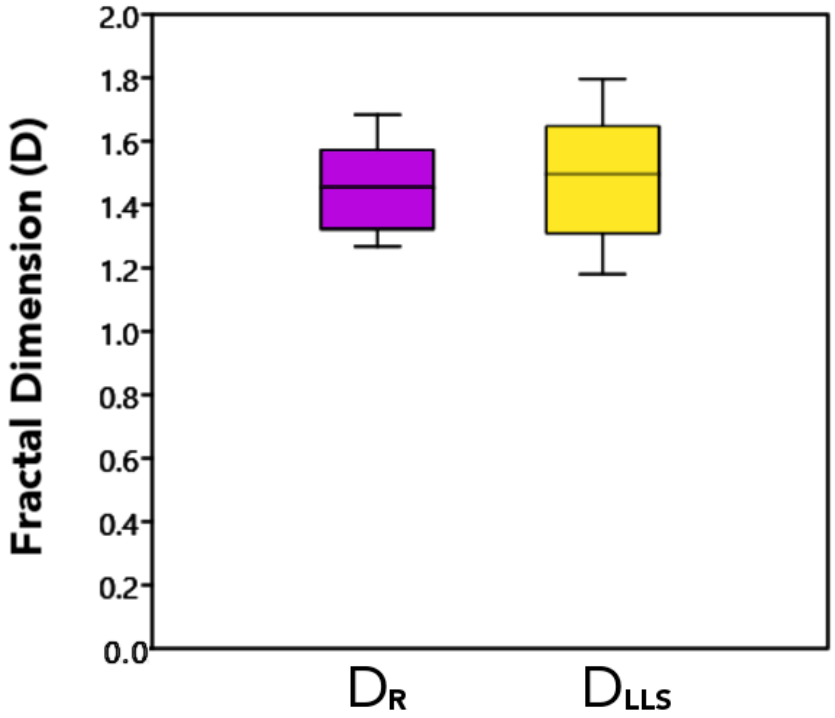
| ***PSILOCERAS* STEP COUNTS (C.V. = 1.55; C.V. = 1.9)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Psiloceras psilononum* | 9 | 25 | -- | 1.365 | 1.367 |
| | 14 | 37 | -- | 1.398 | 1.378 |
| *Psiloceras sp.* | 6 | 22 | -- | 1.450 | 1.292 |
| | 16 | 36 | -- | 1.342 | 1.366 |
| *Psiloceras sp.* | 10 | -- | -- | 1.431 | 1.450 |
| | 16 | -- | -- | | |




Schlegelmilch, R., 1976: Die Ammoniten des suddeutschen Lias. Gustav Fischer Verlag.

Table *Psiloceras*: P36-37

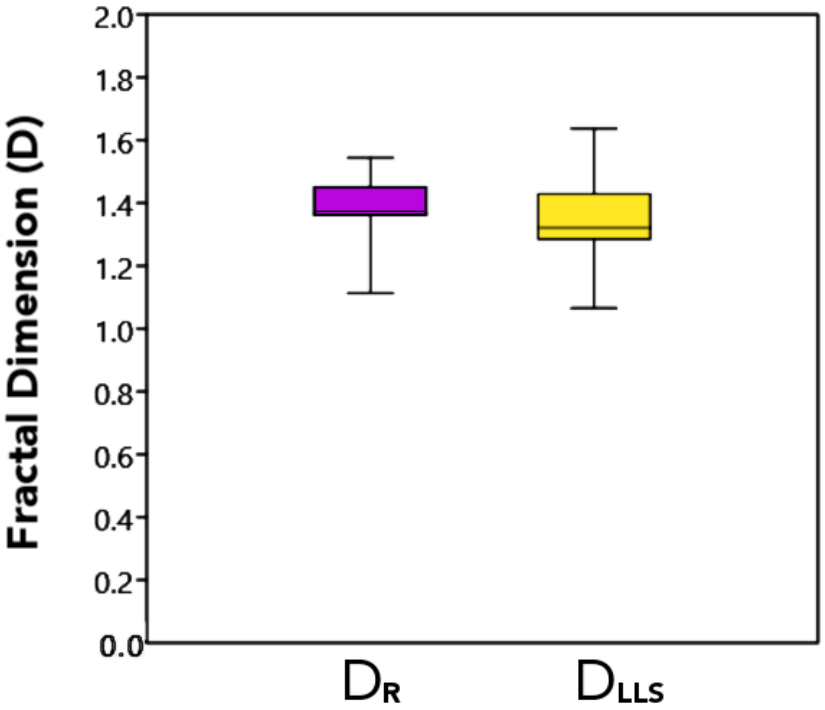
| ***PERISPHINCTES* STEP COUNTS (C.V. ≈ 2)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Perisphinctes microplicatilis* | 10 | 26 | 47 | 1.431 | 1.209 |
| | 14 | 36 | 91 | 1.412 | 1.255 |
| | | | | 1.422 | 1.410 |
| *Perisphinctes chloroolithicus* | 15 | 43 | 76 | 1.683 | 1.617 |
| | 27 | 70 | 130 | 1.633 | 1.544 |
| | | | | 1.599 | 1.541 |
| *Perisphinctes prowitteanus* | 8 | 19 | 31 | 1.292 | 1.000 |
| | 10 | 26 | 49 | 1.279 | 1.114 |
| | | | | 1.268 | 1.181 |
| *Perisphinctes schilli* | 11 | 35 | 52 | 1.490 | 1.461 |
| | 21 | 65 | 109 | 1.544 | 1.512 |
| | | | | 1.459 | 1.476 |




Schlegelmilch, R., 1994: Die Ammoniten des suddeutschen Malms. Gustav Fischer Verlag.

Table *Perisphinctes*: Pages 61-63.*P. microplicatilis, P. chloroolithicus, P. prowitteanus*

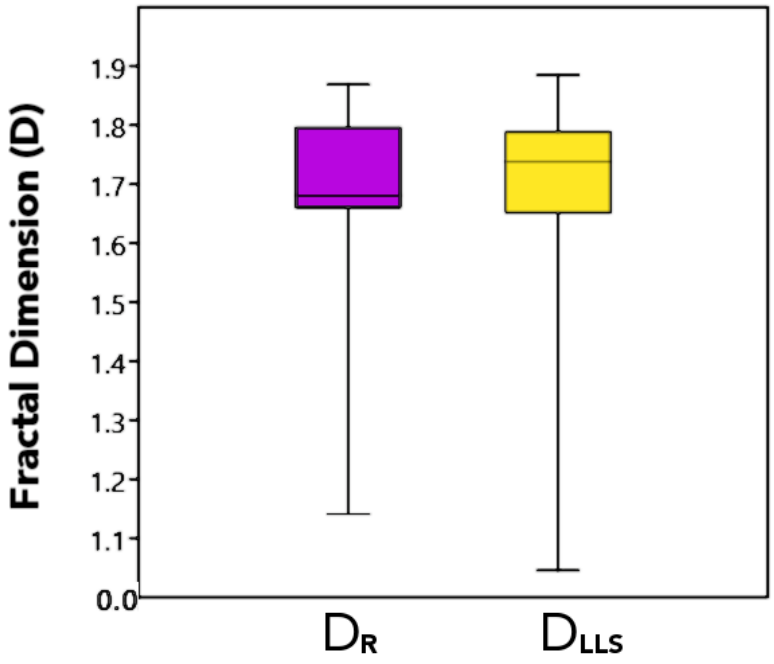
| ***HARPOCERAS* STEP COUNTS (C.V. = 1.44)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Harpoceras falsifier* | 9 | 24 | 40 | 1.365 | 1.367 |
| | 13 | 30 | 54 | 1.380 | 1.319 |
| | | | | 1.362 | 1.338 |
| *Harpoceras elegans* | 9 | 21 | 40 | 1.365 | 1.367 |
| | 13 | 29 | 46 | 1.322 | 1.304 |
| | | | | 1.362 | 1.279 |
| *Harpoceras eseri* | 9 | 29 | 48 | 1.365 | 1.456 |
| | 15 | 34 | 55 | 1.462 | 1.373 |
| | | | | 1.430 | 1.345 |
| *Harpoceras subplanatum*(?) | 6 | 14 | 22 | 1.113 | 1.083 |
| | 8 | 16 | 27 | 1.146 | 1.046 |
| | | | | 1.141 | 1.082 |




Schlegelmilch, R., 1976: Die Ammoniten des suddeutschen Lias. Gustav Fischer Verlag.

Table *Harpoceras*, P. 98-99 *H. falsifier, H. eseri, H. elegans, H. subplanatum*

| ***PHYLLOCERAS* STEP COUNTS (C.V. = 1.3)** | | | | **$D_R$** | **$D_{LLS}$** |
|---|---|---|---|---|---|
| *Phylloceras heterophyllum* | 14 | 52 | 105 | 1.640 | 1.785 |
| | 23 | 84 | 144 | 1.716 | 1.810 |
| | | | | 1.719 | 1.738 |
| *Phylloceras zetes* | 19 | 74 | 133 | 1.829 | 1.785 |
| | 23 | 84 | 144 | 1.869 | 1.810 |
| | | | | 1.806 | 1.738 |
| *Phylloceras cypris* | 15 | 47 | 90 | 1.683 | 1.698 |
| | 20 | 63 | 120 | 1.672 | 1.685 |
| | | | | 1.662 | 1.671 |
| *Phylloceras cypris* (2) | 18 | 48 | 92 | 1.796 | 1.885 |
| | 27 | 76 | 132 | 1.681 | 1.767 |
| | | | | 1.670 | 1.706 |
| *Phylloceras zanebonii* | 18 | 46 | 89 | 1.796 | 1.560 |
| | 16 | 51 | 144 | 1.663 | 1.594 |
| | | | | 1.658 | 1.738 |
| *Phylloceras heterophyllum* | 14 | 52 | 105 | *1.640* | *1.785* |
| | 23 | 84 | 144 | 1.716 | 1.810 |
| | | | | 1.719 | 1.738 |



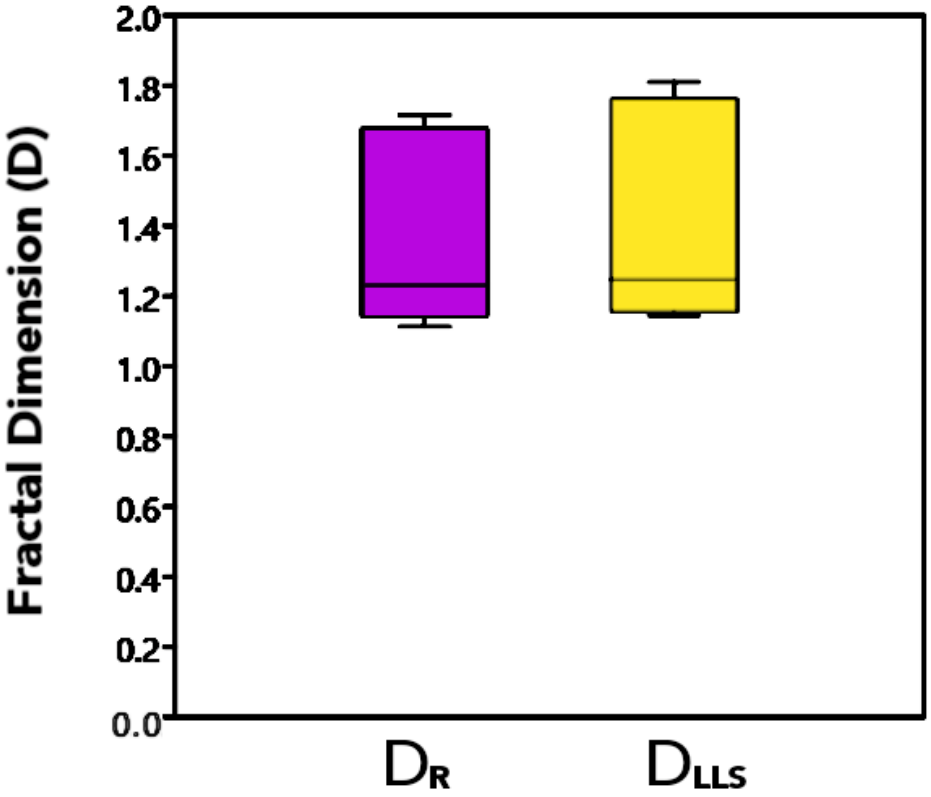

Schlegelmilch, R., 1976: Die Ammoniten des suddeutschen Lias. Gustav Fischer Verlag. Table *Phylloceras*, Pages 27-28.

Schlegelmilch, R., 1994: Die Ammoniten des suddeutschen Lias. Gustav Fischer Verlag. Table Phylloceras, Page 22.

Joly, B., 2008. “Aptian and Albian Phylloceratids (Ammonoidea) from the Vocontian Basin (SE France).” Carnets de Geologie, Carnets de Geologie, 2008, CG2008 (M04), pp.1-60. *Figure 14.*

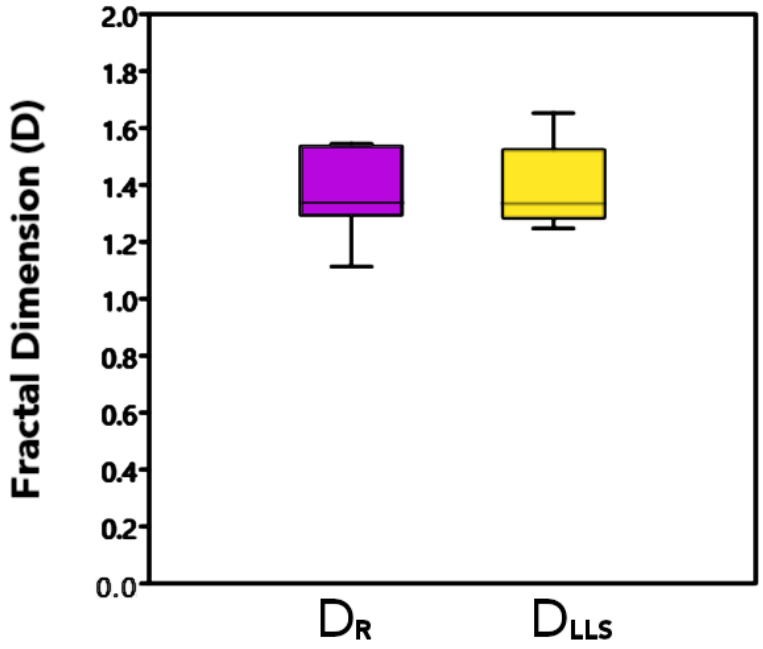
Ifrim, C., Stinnesbeck, W., Garza, R. R., & Ventura, J. F. (2010). Hemipelagic cephalopods from the Maastrichtian (late Cretaceous) Parras Basin at La Parra, Coahuila, Mexico, and their implications for the correlation of the lower Difunta Group. Journal of South American Earth Sciences, 29(3), 597–618. doi:10.1016/j.jsames.2009.08.005

| ***HILDOCERAS* STEP COUNTS (C.V. = 1.4)** | | | | **$D_R$** | **$D_{LLS}$** |
|---|---|---|---|---|---|
| *Hildoceras bifrons* | 6 | 14 | 22 | 1.113 | 1.156 |
| | 9 | 20 | 32 | 1.146 | 1.155 |
| | | | | 1.141 | 1.156 |
| *Hildoceras semipolitum* | 7 | 17 | 28 | 1.209 | 1.222 |
| | 10 | 25 | 41 | 1.230 | 1.252 |
| | | | | 1.230 | 1.247 |
| *Hildoceras sublevisoni* | 8 | 22 | 37 | 1.292 | 1.335 |
| | 12 | 27 | 41 | 1.342 | 1.285 |
| | | | | 1.333 | 1.247 |




4. Schlegelmilch, R., 1976: Die Ammoniten des suddeutschen Lias. Gustav Fischer Verlag. Table *Hildoceras*, Pages 96-97.

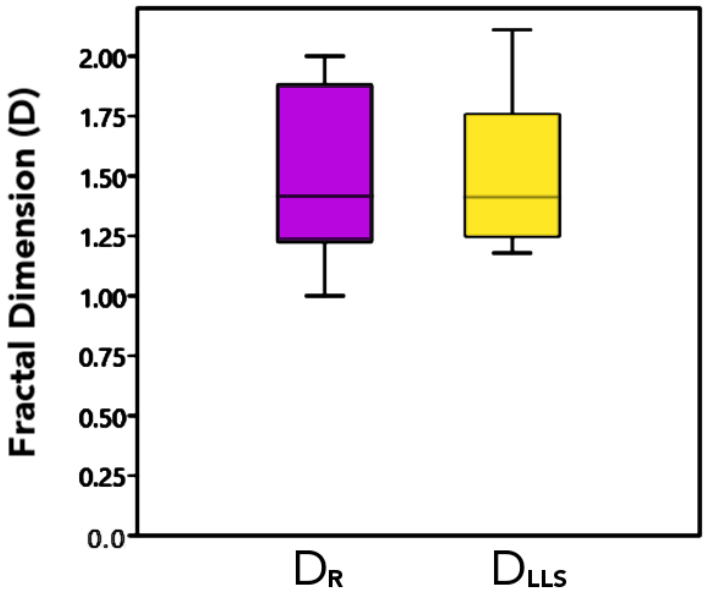
| ***SCAPHITES* STEP COUNTS (C.V. = 1.65)** | | | | **$D_R$** | **$D_{LLS}$** |
|---|---|---|---|---|---|
| *Scaphites hippocrepis* f. | 5 | 18 | 32 | 1.000 | 1.179 |
| | 11 | 30 | 51 | 1.255 | 1.260 |
| | | | | 1.280 | 1.267 |
| *Scaphites hippocrepis* m. | 6 | 16 | 27 | 1.113 | 1.179 |
| | 11 | 26 | 51 | 1.204 | 1.197 |
| | | | | 1.217 | 1.267 |
| *Scaphites gilli* | 6 | 26 | 45 | 1.113 | 1.518 |
| | 19 | 49 | 84 | 1.415 | 1.472 |
| | | | | 1.406 | 1.451 |
| *Scaphites gilli* 2 | 7 | 24 | 40 | 1.209 | 1.518 |
| | 19 | 40 | 69 | 1.380 | 1.385 |
| | | | | 1.362 | 1.379 |




Cobban, W.A., 1969: The Late Cretaceous ammonites Scaphites leei Reeside and Scaphites hippocrepis DeKay in the western interior of the United States. USGS Professional Paper 619. https://doi.org/10.3133/pp619 *Figure 18*.

Cobban, W. A., and J. A. Jeletzky. "A New Scaphite from the Campanian Rocks of the Western Interior of North America." Journal of Paleontology, vol. 39, no. 5, Paleontological Society, 1965, pp. 794–801, http://www.jstor.org/stable/3555306. *Figure 2.*

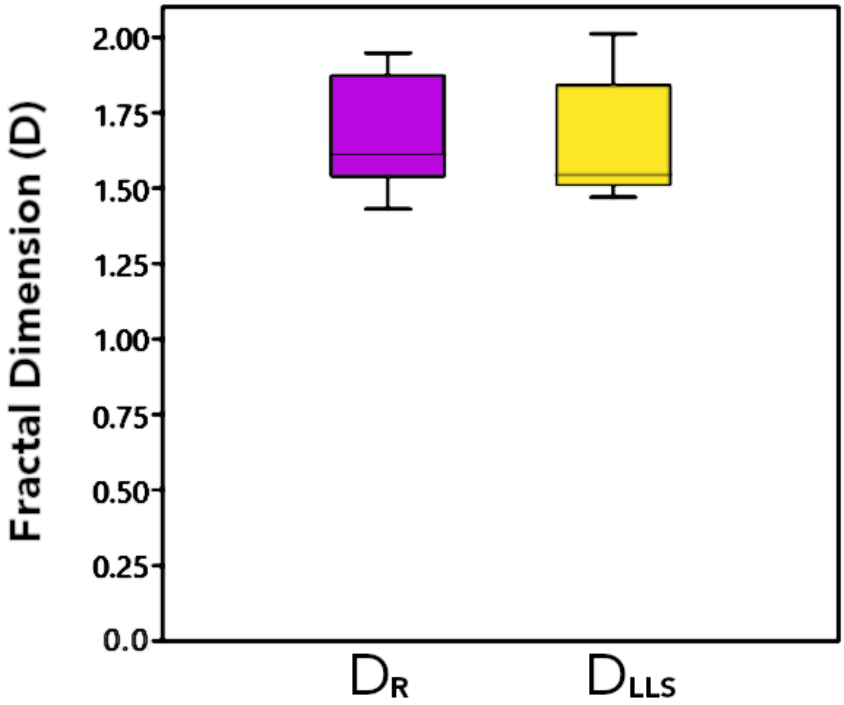
| ***BACULITES* STEP COUNTS (*C.V. = 1; **C.V. = 2)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| **Baculites scotti* long side | 21 | 69 | 123 | 1.892 | 1.948 |
| | 23 | 58 | 111 | 1.839 | 1.763 |
| | | | | 1.777 | 1.739 |
| **Baculites scotti* short side | 25 | 82 | -- | 2.000 | 2.113 |
| | 30 | 64 | -- | 1.914 | 1.806 |
| ***Baculites eliasi* | 11 | 30 | -- | 1.490 | 1.594 |
| | 26 | 69 | -- | 1.477 | 1.538 |
| ***Baculites eliasi* 2 | 11 | 35 | -- | 1.490 | 1.594 |
| | 26 | 69 | -- | 1.477 | 1.538 |
| **Baculites grandis* | 7 | 20 | 39 | 1.544 | 1.538 |
| | 13 | 40 | 69 | 1.209 | 1.163 |
| | | | | 1.301 | 1.301 |
| ***Baculites inornatus* | 9 | 29 | -- | 1.353 | 1.308 |
| | 16 | 48 | -- | 1.365 | 1.292 |
| ***Baculites rex* | 11 | 28 | -- | 1.462 | 1.380 |
| | 21 | 60 | | 1.490 | 1.461 |




Cobban, W. A., 1962: Baculites from the Lower Part of the Pierre Shale and Equivalent Rocks in the Western Interior. Journal of Paleontology, 36(4), 704–718. http://www.jstor.org/stable/1301354. *Figure 1.*

Cobban, W. A. "Two New Species of Baculites from the Western Interior Region." Journal of Paleontology, vol. 32, no. 4, Paleontological Society, 1958, pp. 660–65. *Figure 1.*

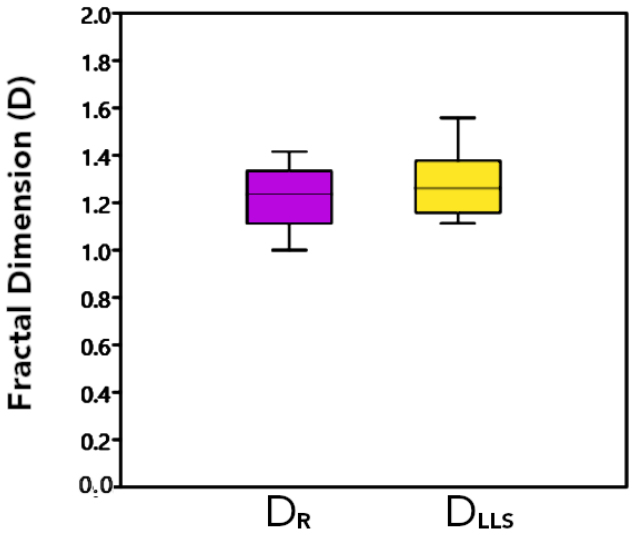
| ***PACHYDISCUS* STEP COUNTS (*C.V. = 1.2; **C.V. = 2)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Pachydiscus macroensis* | 20 | 80 | 162 | 1.861 | 2.012 |
| | 51 | 148 | 272 | 1.903 | 1.869 |
| | | | | 1.867 | 1.840 |
| *Pachydiscus egertoni* | 24 | 74 | 157 | 1.875 | 1.789 |
| | 34 | 93 | 175 | 1.872 | 1.753 |
| | | | | 1.640 | 1.544 |
| *Pachydiscus sp.* | 23 | 75 | 159 | 1.613 | 1.511 |
| | 39 | 123 | 231 | 1.599 | 1.486 |
| | | | | 1.431 | 1.543 |
| *Pachydiscus* cf. *flexuosus* | 14 | 41 | 76 | 1.613 | 1.511 |
| | 24 | 65 | 112 | 1.599 | 1.486 |
| | | | | 1.431 | 1.544 |
| *Pachydiscus* cf. *flexuosus* (2) | 10 | 31 | 65 | 1.491 | 1.512 |
| | 24 | 65 | 107 | 1.541 | 1.470 |




21. Dias-Canas and Patarroyo, 2010. Vista de Pachydiscus del Campaniano Superior – Maastrichtiano Inferior de la formación Penderisco, cordillera occidental (Antioquia – Colombia) *Figure 4.*

20. Ifrim, C., Stinnesbeck, W., Garza, R. R., & Ventura, J. F. (2010). Hemipelagic cephalopods from the Maastrichtian (late Cretaceous) Parras Basin at La Parra, Coahuila, Mexico, and their implications for the correlation of the lower Difunta Group. Journal of South American Earth Sciences, 29(3), 597–618. doi:10.1016/j.jsames.2009.08.005 *Figure 5, n-s.*

| ***PLACENTICERAS* STEP COUNTS (C.V. = 2)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Placenticeras costatum* | 6 | 18 | 42 | 1.113 | 1.113 |
| | 12 | 34 | 68 | 1.255 | 1.230 |
| | | | | 1.333 | 1.302 |
| *Placenticeras pingue* | 6 | 18 | 37 | 1.113 | 1.113 |
| | 12 | 34 | 68 | 1.255 | 1.230 |
| | | | | 1.380 | 1.302 |
| *Placenticeras pingue* 2 | 6 | 18 | 37 | 1.113 | 1.292 |
| | 16 | 41 | 79 | 1.255 | 1.312 |
| | | | | 1.333 | 1.358 |
| *Placenticeras meeki* | 5 | 14 | 27 | 1.000 | 1.163 |
| | 13 | 28 | 52 | 1.146 | 1.146 |
| | | | | 1.217 | 1.203 |
| *Placenticeras meeki* 2 | 7 | 26 | -- | 1.209 | 1.431 |
| | 20 | 66 | -- | 1.415 | 1.516 |

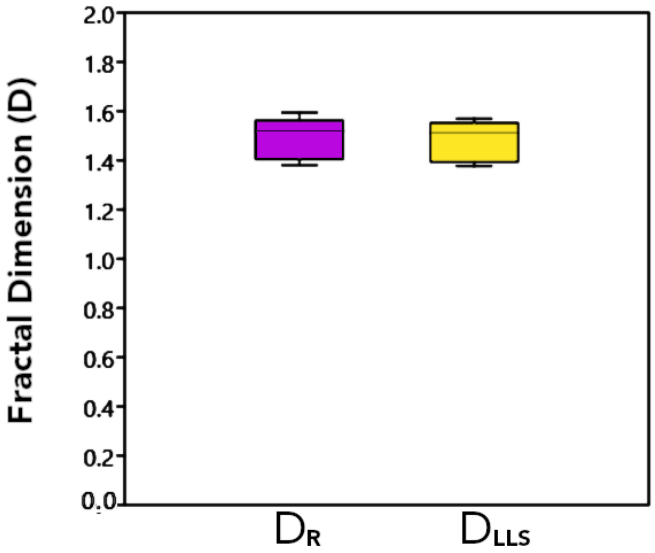



Kennedy, W.J., Cobban, W.A., and Landman, N.H., 1996: Two species of Placenticeras (Ammonitina) from the Upper Cretaceous (Campanian) of the Western Interior of the United States. American Museum Novitates. *Figure 24, Figure 28.*

Reeside, J.B., 1926: A comparison of the genera Metaplacenticeras Spath and Placenticeras Meek. Shorter Contributions to General Geology, USGS. report.pdf (usgs.gov) *Figure 5.*

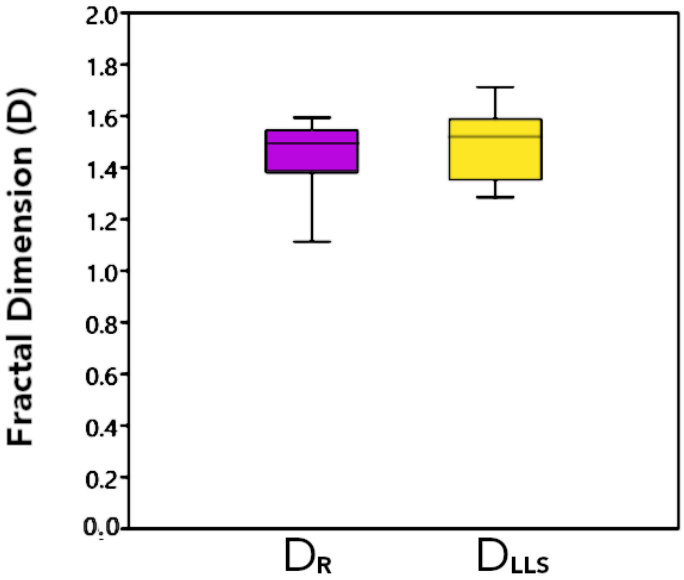
Natural history Museum: Suture Patterns within Subclass Ammonoidea | Natural History Museum. (n.d.). Retrieved September 21, 2021, from https://natmus.humboldt.edu/exhibits/fossil-focus-exhibits/suture-patterns-within-subclass-ammonoidea. *Placenticeras intercalare Figure 618* 618.jpg (582×480) (humboldt.edu)

| ***STEPHANOCERAS* STEP COUNTS (C.V. = 1.2) (166-170)** | | | | **$D_R$** | **$D_{LLS}$** |
|---|---|---|---|---|---|
| *Stephanoceras sp.* | 13 | 33 | 63 | 1.594 | 1.569 |
| | 15 | 41 | 72 | 1.519 | 1.534 |
| | | | | 1.530 | 1.512 |
| *Stephanoceras sp.* 2 | 10 | 24 | -- | 1.431 | 1.377 |
| | 11 | 31 | | 1.380 | 1.412 |




Lominazde, T., Sharikazde, M., and Kvantaliani, I., 1993. "Phylogeny and systematics of Perisphinctids as interpreted from suture ontogenies." Geobios, Volume 26, Supplement 1, *Figure 12.*

| ***DORSOPLANITES* STEP COUNTS (C.V. = 1.4)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Dorsoplanites dorsoplanus* | 12 | 30 | 60 | 1.544 | 1.652 |
| | 20 | 52 | 94 | 1.477 | 1.570 |
| | | | | 1.512 | 1.553 |
| *Dorsoplanites gracilis* | 6 | 20 | 34 | 1.113 | 1.335 |
| | 12 | 27 | 46 | 1.301 | 1.285 |
| | | | | 1.302 | 1.290 |
| *Dorsoplanites primitivus* | 12 | 35 | 72 | 1.544 | 1.514 |
| | 16 | 47 | 41 | 1.544 | 1.526 |
| | | | | 1.371 | 1.455 |
| *Dorsoplanites antiquus* | 13 | 35 | -- | 1.594 | 1.683 |
| | 21 | 54 | -- | 1.544 | 1.586 |
| | | | | 1.544 | 1.587 |
| *Dorsoplanites transitorius* | 12 | 28 | -- | 1.447 | 1.507 |
| | 18 | 45 | -- | 1.431 | 1.335 |
| *Dorsoplanites crassus* | 10 | 26 | -- | 1.415 | 1.410 |
| | 12 | 36 | -- | 1.544 | 1.712 |
| *Dorsoplanites subpanderi* | 12 | 34 | -- | 1.531 | 1.302 |
| | 22 | 56 | -- | | |

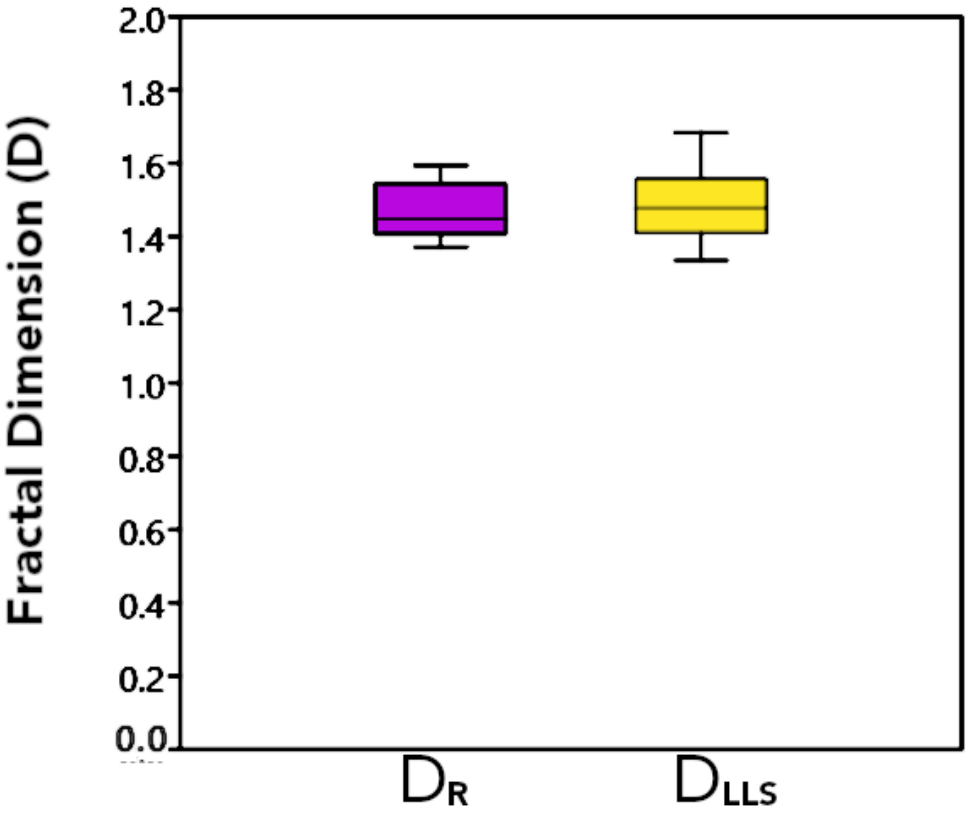



Mikhailov, 1963. Boreal Jurassic ammonites (Dorsoplanitinae) and zonal subdivision of the Volgian Stage. Academy of Sciences of the USSR, Geological Institute. *Figures 1-5, 7, 10.*

Lominazde, T., Sharikazde, M., and Kvantaliani, I., 1993. "Phylogeny and systematics of Perisphinctids as interpreted from suture ontogenies." Geobios, Volume 26, Supplement 1, *Figure 3.*

Schlegelmilch, R., 1994: Die Ammoniten des suddeutschen Malms. Gustav Fischer Verlag.

| ***HOLCOLYTOCERAS* STEP COUNTS (C.V. = 1.2)** | | | | $D_R$ | $D_{LLS}$ |
|---|---|---|---|---|---|
| *Holcolytoceras nodostrictum* | 11 | 30 | -- | 1.490 | 1.526 |
| | 14 | 36 | -- | 1.477 | 1.477 |
| *Holcolytoceras nodostrictum* 2 | 10 | 25 | 42 | 1.431 | 1.431 |
| | 12 | 34 | 61 | 1.398 | 1.452 |
| | | | | 1.380 | 1.451 |

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**File S2: Curvature vs. Flatness** ***also attached as a separate Excel document***

| PLACENTI | PLACENTICERAS FLA | | GAUDRYCI | GAUDRYCERAS FLAT | | LYTOCERA | LYTOCERAS FLAT | | PACHYDIS | PACHYDISCUS FLAT | | CADOCER | CADOCERAS FLAT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.209 | 1.113 | | 1.484 | 1.906 | | 1.602 | 1.781 | | 1.715 | 2.012 | | 1.136 | 1.145 | |
| 1.38 | 1.23 | | 1.461 | 1.681 | | 1.7 | 1.68 | | 1.829 | 1.869 | | 1.198 | 1.198 | |
| 1.415 | 1.302 | | 1.332 | 1.653 | | 1.676 | 1.65 | | 1.736 | 1.84 | | 1.253 | | |
| 1.33 | 1.113 | | 1.461 | 1.683 | | 1.723 | 1.88 | | | 1.789 | | 1.284 | | |
| 1.455 | 1.23 | | 1.415 | 1.628 | | | 1.791 | | | 1.753 | | | | |
| | 1.302 | | 1.525 | 1.569 | | | 1.735 | | | 1.544 | | | | |
| | 1.292 | | 1.716 | 1.591 | | | 1.88 | | | 1.511 | | | | |
| | 1.312 | | 1.846 | 1.662 | | | 1.774 | | | 1.456 | | | | |
| | 1.358 | | 1.736 | 1.597 | | | 1.743 | | | 1.543 | | | | |
| | 1.163 | | | 2 | | | 1.861 | | | 1.511 | | | | |
| | 1.146 | | | 1.863 | | | 1.76 | | | 1.486 | | | | |
| | 1.203 | | | 1.786 | | | 1.675 | | | 1.544 | | | | |
| | 1.431 | | | 1.683 | | | 1.88 | | | | | | | |
| | 1.516 | | | 1.461 | | | 1.791 | | | | | | | |
| | | | | 1.4609 | | | 1.726 | | | | | | | |
| | | | | 1.579 | | | 1.581 | | | | | | | |
| | | | | | | | 1.416 | | | | | | | |
| | | | | | | | 1.412 | | | | | | | |
| | | | | | | | 1.416 | | | | | | | |

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