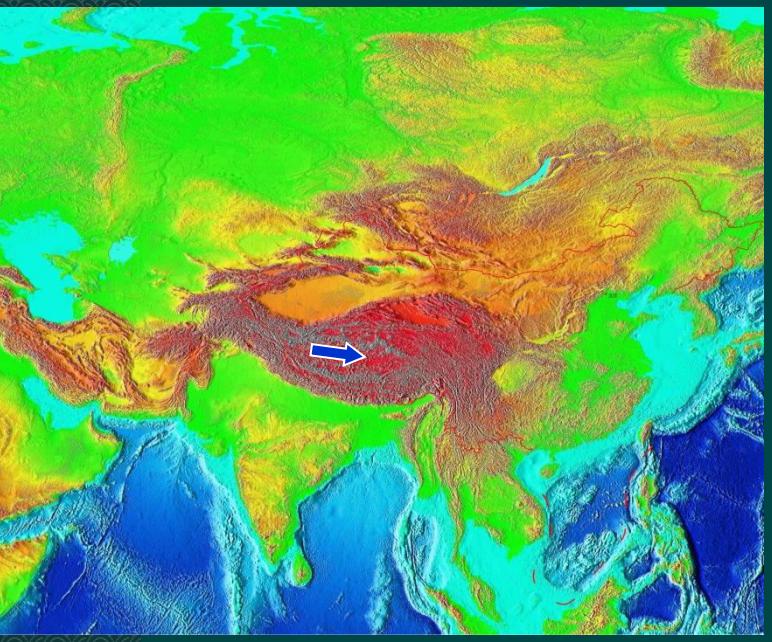
Pan-tropical distribution of the Jurassic ostreid bivalves and factors control

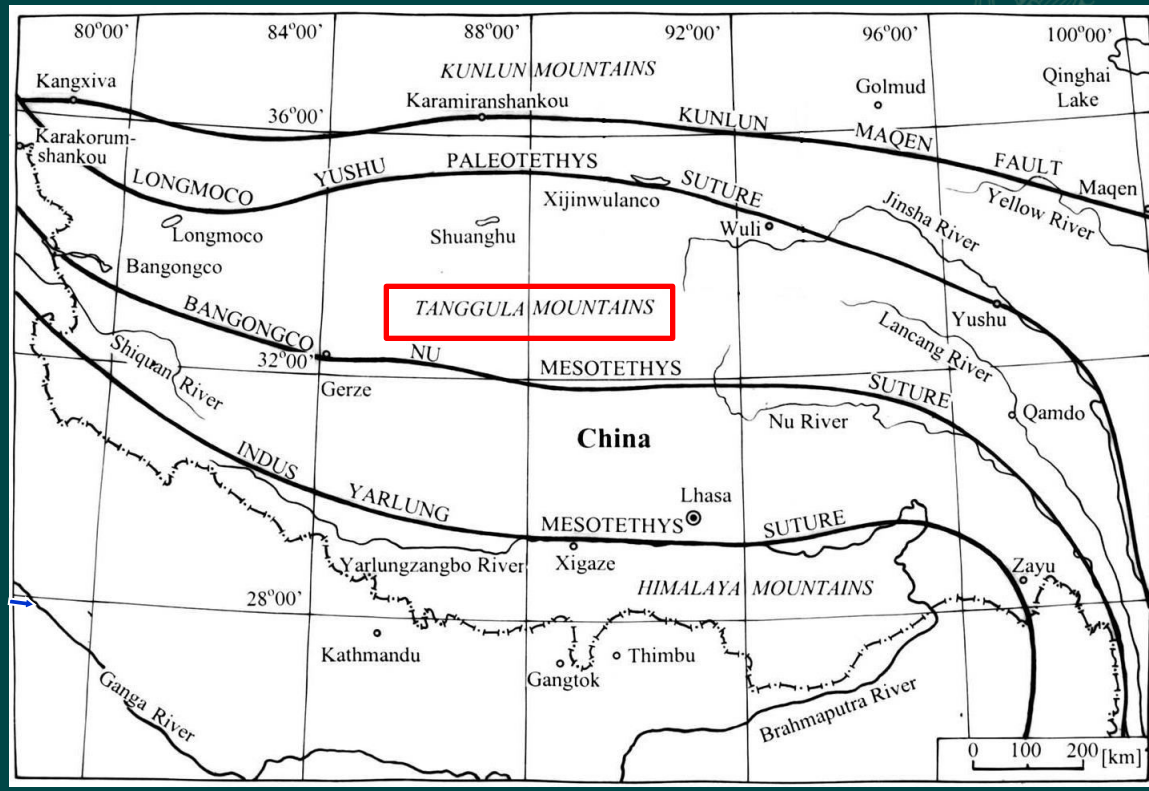
Jingeng Sha

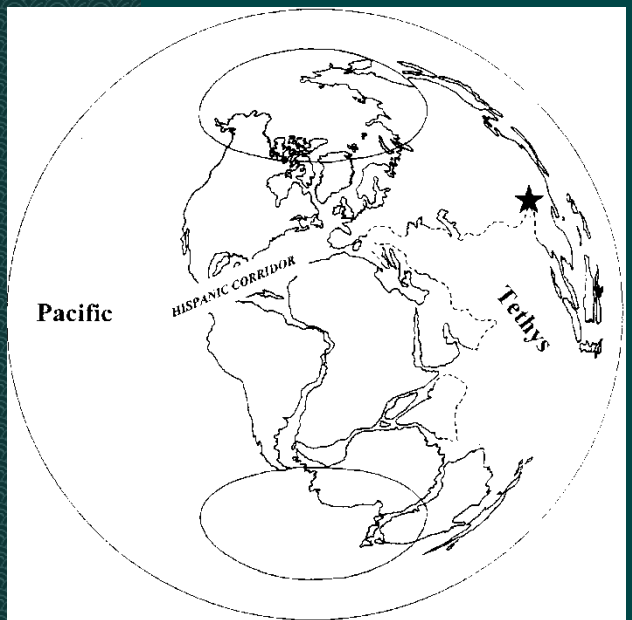
LPS, Nanjing Institute of Geology and Palaeontology, CAS

Tanggula Mountains yielding Jurassic ostreid bivalves

Tectonics of Qinghai-Xizang (Tibet) Plateau



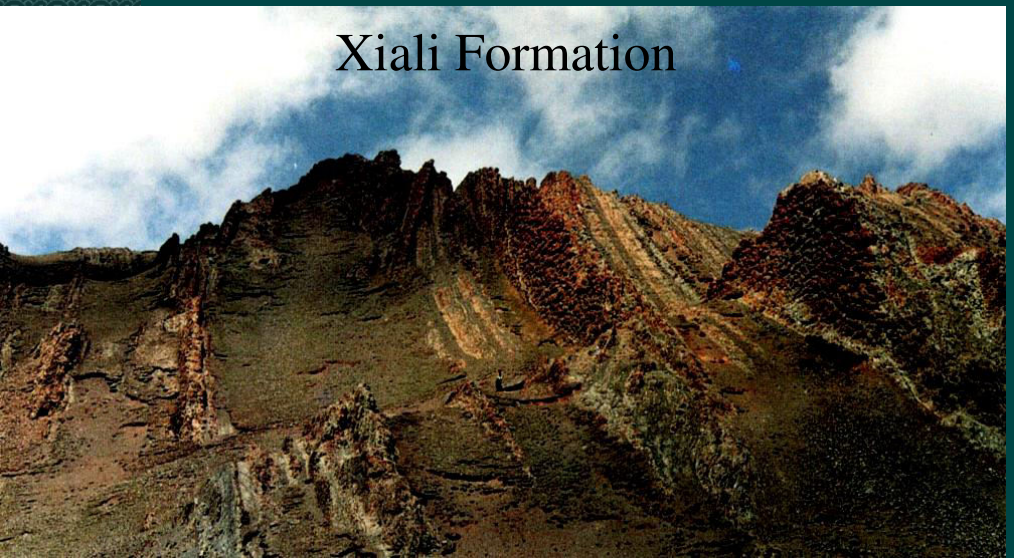


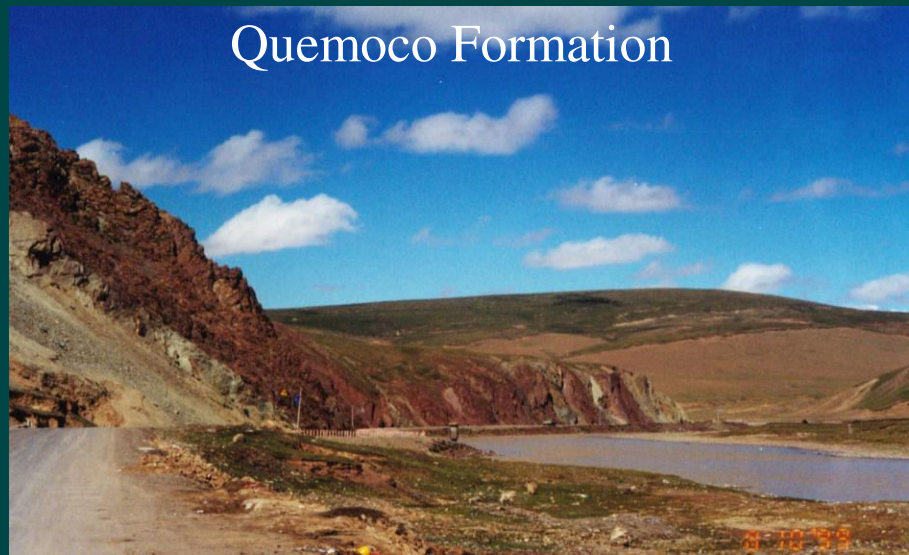


Palaeogeographically, in the Jurassic it was located at the northeastern side of the Tethys, linking the northern Tethys with the northwestern Palaeo-Pacific

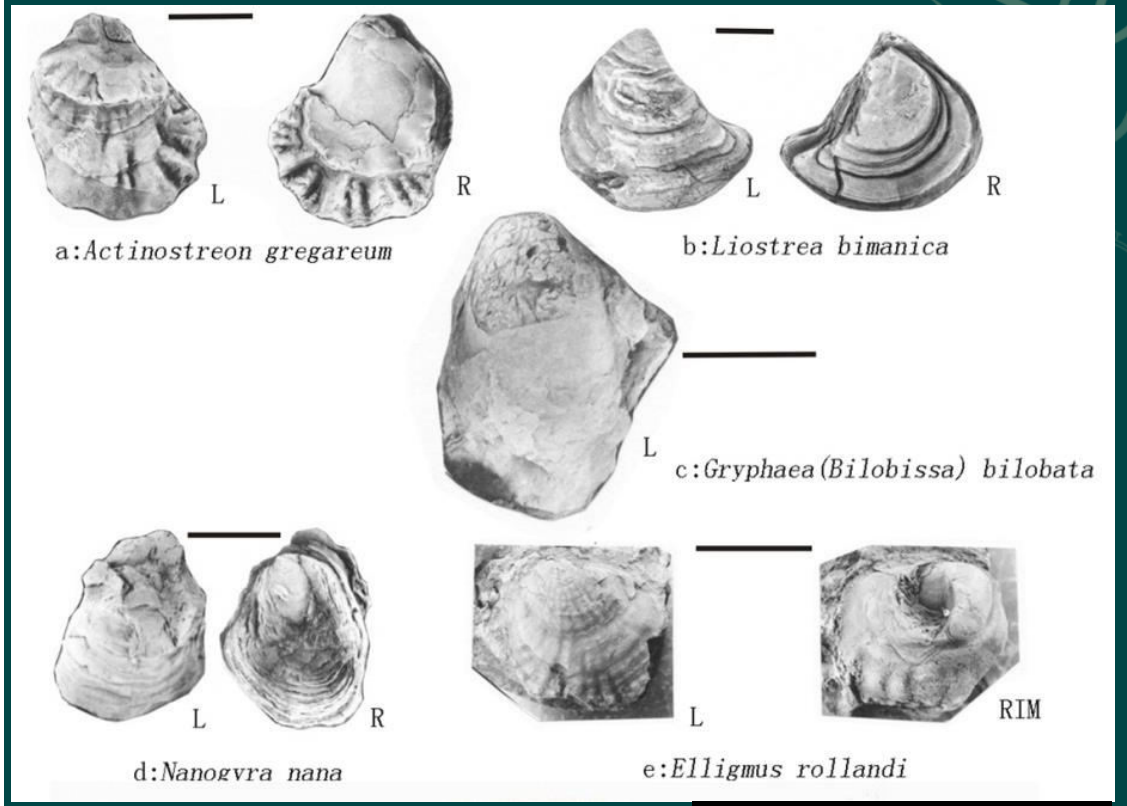
Middle Jurassic Bathonian—Oxfordian







Eonothem Eon	Erathem Era	System Period	Series Epoch	Stage Age	Age Ma	GSSP
Mesozoic	Mesozoic	Cretaceous	Upper	Danian	65.5 ±0.3	▲
				Maastrichtian	70.6 ±0.6	▲
				Campanian	83.5 ±0.7	
				Santonian	85.8 ±0.7	
				Coniacian	~ 88.6	
				Turonian	93.6 ±0.8	▲
				Cenomanian	99.6 ±0.9	▲
			Lower	Albian	112.0 ±1.0	
				Aptian	125.0 ±1.0	
				Barremian	130.0 ±1.5	
				Hauterivian	~ 133.9	
				Valanginian	140.2 ±3.0	
				Berriasian	145.5 ±4.0	
Mesozoic	Mesozoic	Jurassic	Upper	Tithonian	150.8 ±4.0	
				Kimmeridgian	~ 155.6	
			Middle	Oxfordian	161.2 ±4.0	
				Callovian	164.7 ±4.0	
				Bathonian	167.7 ±3.5	▲
				Bajocian	171.6 ±3.0	▲
				Aalenian	175.6 ±2.0	▲
			Lower	Toarcian	183.0 ±1.5	
				Pliensbachian	189.6 ±1.5	▲
				Sinemurian	196.5 ±1.0	▲
				Hettangian	199.6 ±0.6	▲
				Rhaetian		







Geographical and geological ditribution of the Jurassic oystreid from Tanggula, western China

~ 20 countries

Early–Late Jurassic (145—196 Ma)

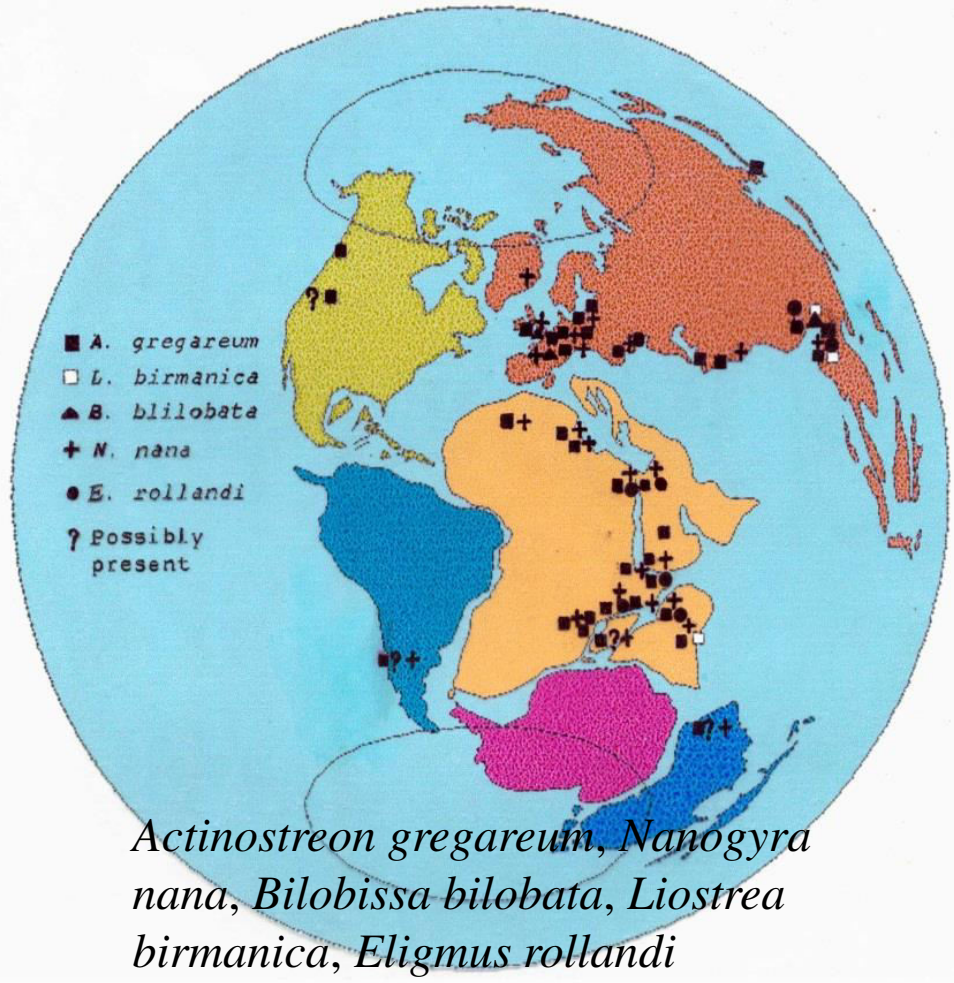
Species	*Actinostreon gregareum*	*Liostrea birmanica*	*Gryphaea (Bilobissa) bilobata*	*Nanogyra nana*	*Eligmus rollandi*
1 Tanggula	Bath.-Oxf.	Bath. Oxf.	Bath.	Bath.-Oxf.	Cal.-Oxf.
2 Utzbekistan Turkmenistan	Bath.				
3 Dnestr-Prut Crimea	Cal.			Kim.	
4 Westerm Europe	?Toar.-Kim.		Baj. Bath.	Baj.-Tith.	
5 North Africa	Baj.-Tith.			Baj.-Tith.	
6 Sina Israel Jordan	Baj.-Oxf.			Baj.-Kim.	Bath.-Cal.
7 Iran Afghanistan	Baj.-Bath.			Bath.-Cal.	
8 Centre and south Arabia	Oxf.-Kim.			Oxf.	
9 East Africa	Toar.-Kim.			Toar.-Kim.	Cal.-Oxf.
10 Kachchh Nepal South Xizang	Bath.-Kim	Bath-kim.		Bath.-Oxf.	Bath.
11 Western Australia	Baj.			Baj.	
12 Yunnan Burma	Bath-. Kim.	Bath-kim.		Bath.-Oxf.	Bath.-Kim.
13 East Greenland				Oxf.-Tith.	
14 Western Canada	Baj-. ?Bath				
15 Northern Canada	Sin.-Aal.			L.J.	
16 Japan	U.J.				
17 Agentina	Sin.-Aal.		Sin.-Aal.	Sin.-Aal.	

(Sha, 2001)

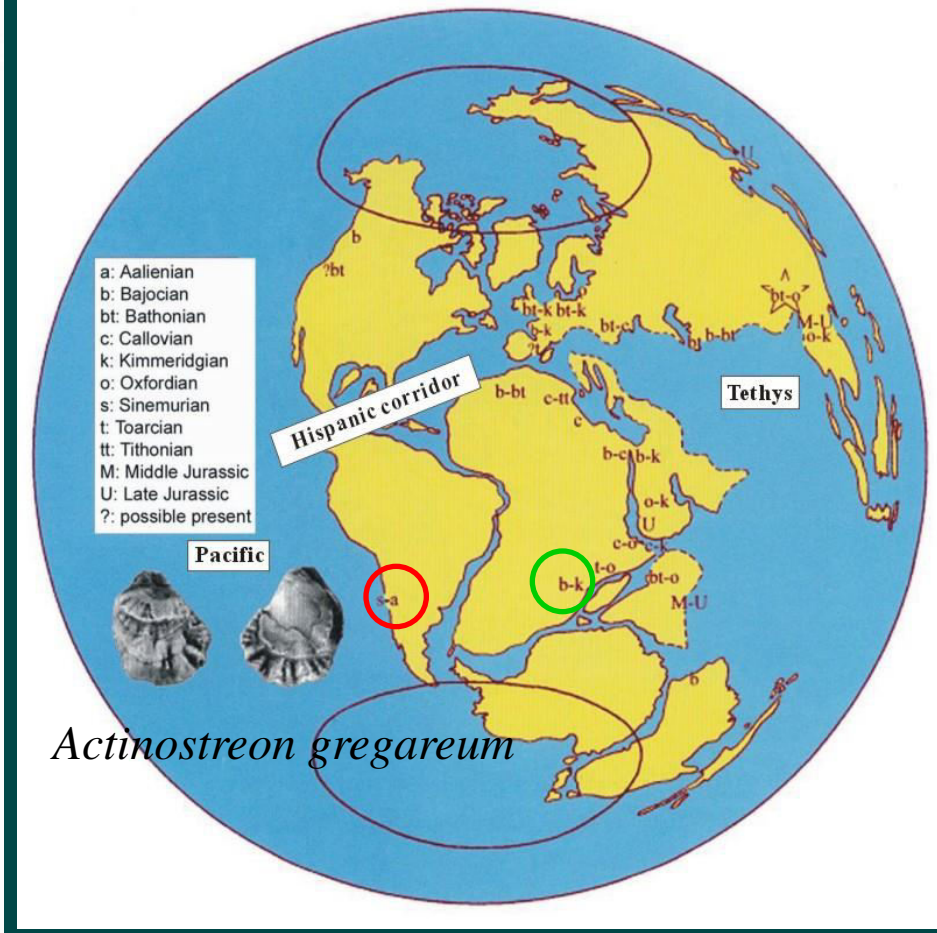
Pantropically/antipolarly distributed

All limited between palaeo-latitudes 60 degree of South and North during the Jurassic.

Thermophilic



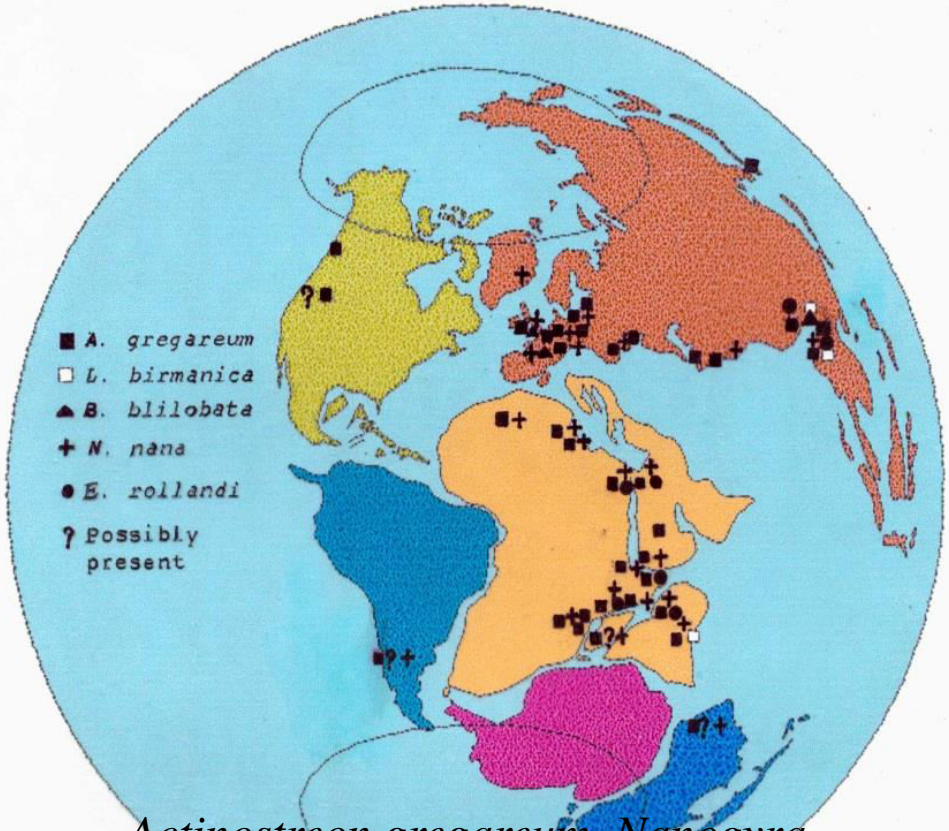
Actinostreon gregareum, *Nanogyra nana*, *Bilobissa bilobata*, *Liostrea birmanica*, *Eligmus rollandi*



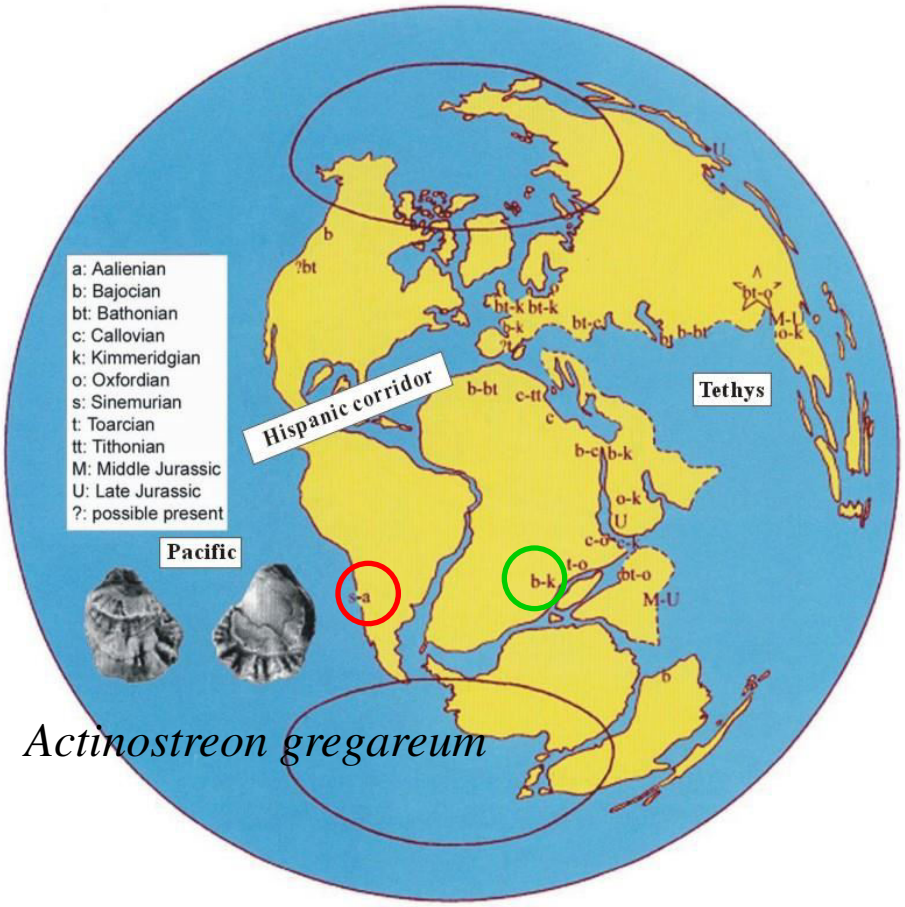
Actinostreon gregareum

(Sha, 2002; Sha et al., 2002, 2014)

How did the epi-cemented thermophilic pantropical bivalves complete a trans-palaeo-Pacific journey to do interchanges between east and west Pacific?



Actinostreon gregareum, *Nanogyra nana*, *Bilobissa bilobata*, *Liostrea birmanica*, *Eligmus rollandi*



Actinostreon gregareum

(Sha, 2002; Sha et al., 2002, 2014)

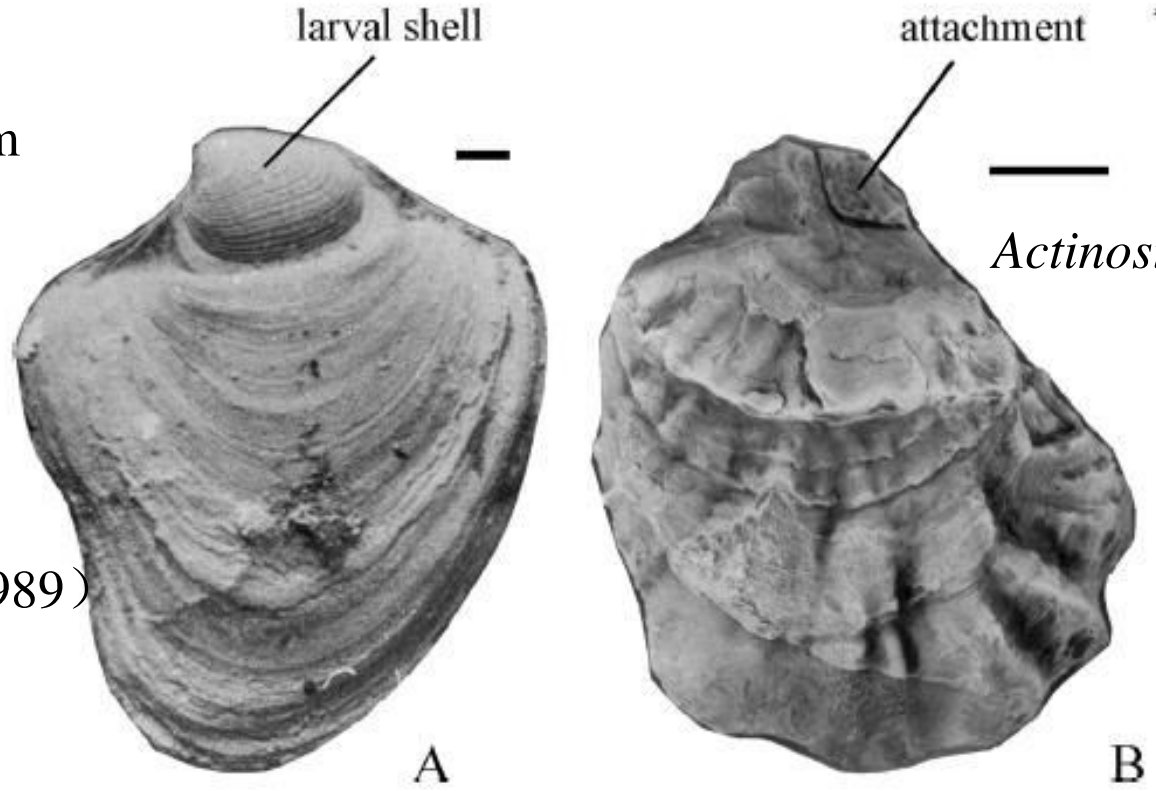
Factors controlling the dispersal of Jurassic ostreid bivalves

- Temperature
- Length of planktonic larval stage
- Pseudoplanktonic mode of life during the adult stage
- Opportunistic behavior
- Precocity
- High productivity
- Longevity
- Seaways
- Island stepping stones
- Eustatic sea level changes
- Ocean currents

Planktotrophic larval shell and attachment

Scalebar: 100 μm

Lisotrea plastica
（after Palmer1989）



Actinostreon gregareum

Planktong during larval stage

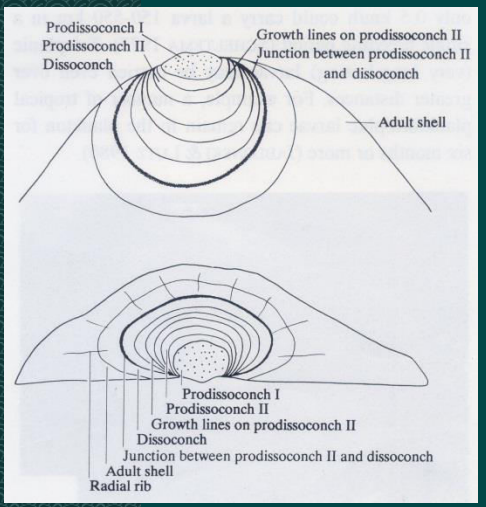
Passively drifting/swimming, transported with ocean currents.

Teleplantic ones up to more than 6 months, even more than 12 months (0.5km/hour, 150–500km in 2–6 weeks).

Sense suitable environments for surviving and colonization, delay metamorphosis or settlement to reduce mortality and find a hospitable habitat.

Planktotrophic larval shell

Liostrea



Diagram

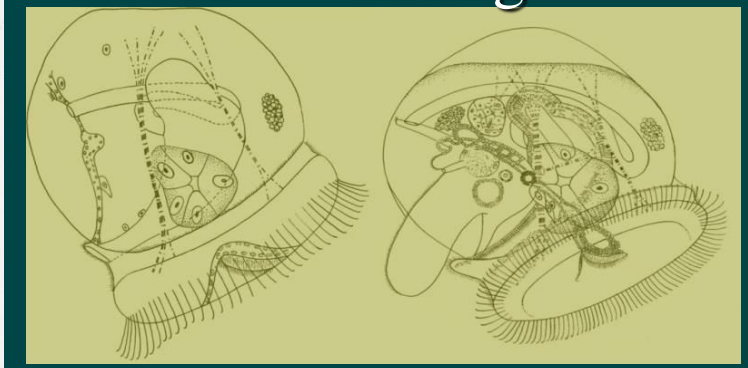
type of larva	prodisso-conch I	prodisso-conch II	boundary between prodisso-conch and dissoconch
plankto-trophic	small 70-150 μm devoid of ornament	large 200-600 μm with growth lines	very sharp
non-plankto-trophic	large 135-230 μm	small or absent	obscure or absent

Distinctions between planktotrophic and non-palnktotrophic larval shells



Fossil

Living



Veliger larva without peliveliger Six-day old

Peliveliger larva with Peliveliger

(Sha, 1991，2003；Sha et al., 1994, 2014)

Pseudoplanton in post larval stage

Attached to (cementing to) movable objects including drift woods, cephalopods, ecnoids, etc., as pseudoplanktic guests, to disperse with currents, which exceptionally could serve as floats for a few years.

Attachment



Liostrea mirmanica



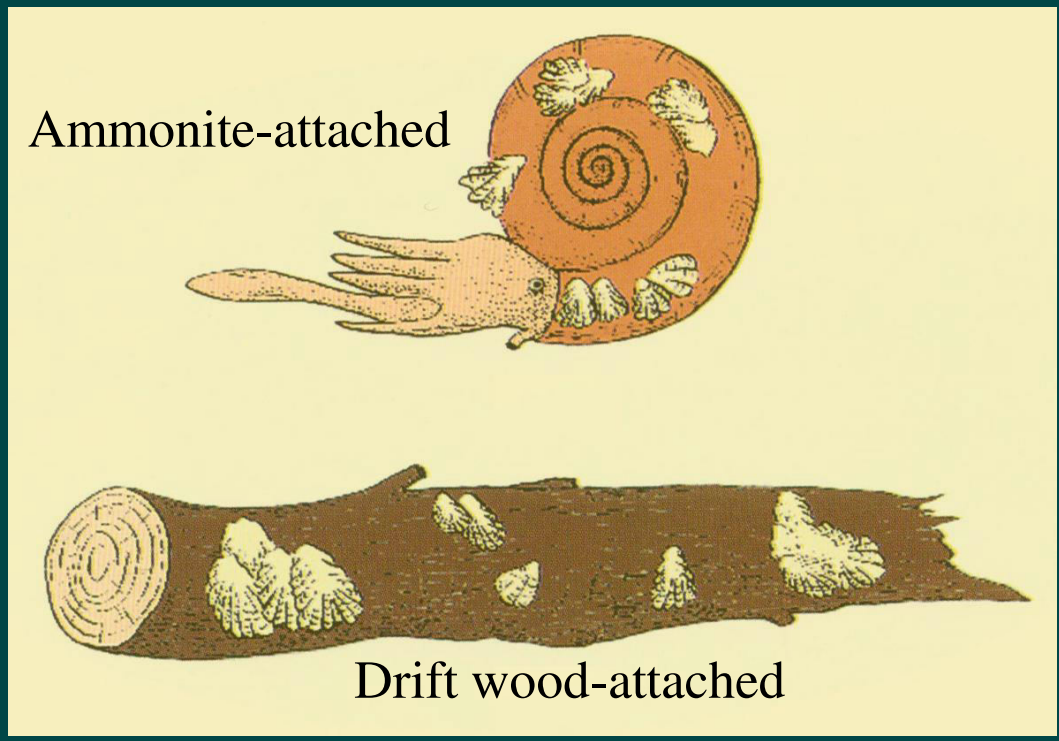
Actinostreon gregareum



Nanogyra nana



Eligmus rollandi





A mangrove oyster *Crassostrea virginica* (Gmelin, 1791) growing in crotch of mangrove stilt, near Comalcalco, State of Tabasco, Mexico, x1.4 (Stenzel, n. Specimen donated by J. D. Stoen).

High productivity, Opportunist, Precocity, Longevity

Like living ones, byssate and cemented, with Planktotrophic larval bivalves have very high reproduction rates (99–170 millions eggs individual in a single spawning) to counterbalance the extremely high larval mortality.

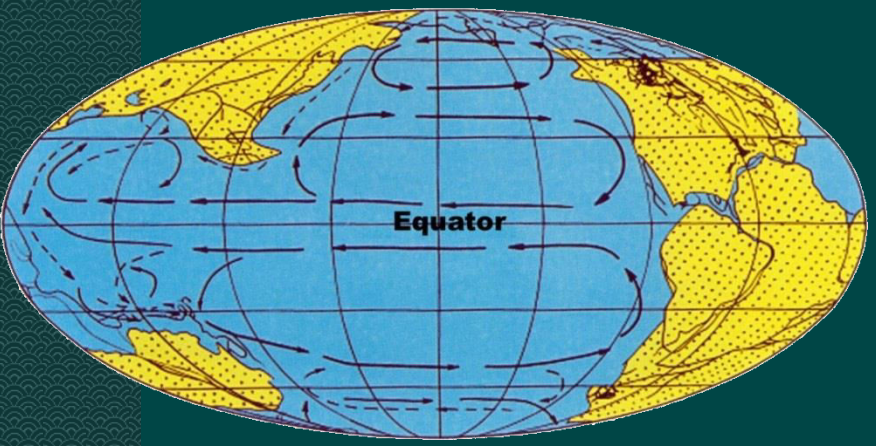
At least some of the pantropic bivalves are non-resources-limited opportunists or "r-strategists" or "environment breakers" or facies-crossing molluscs, primarily controlled by the physical rather than the biotic environment, being able to colonize marginal environments.

Living oysters can have a life span of more than 25 years and Miocene ones more than 47, Cretaceous bivalves could span several stages. Such longevous bivalves could migrate or be carried far distances in a single generation.

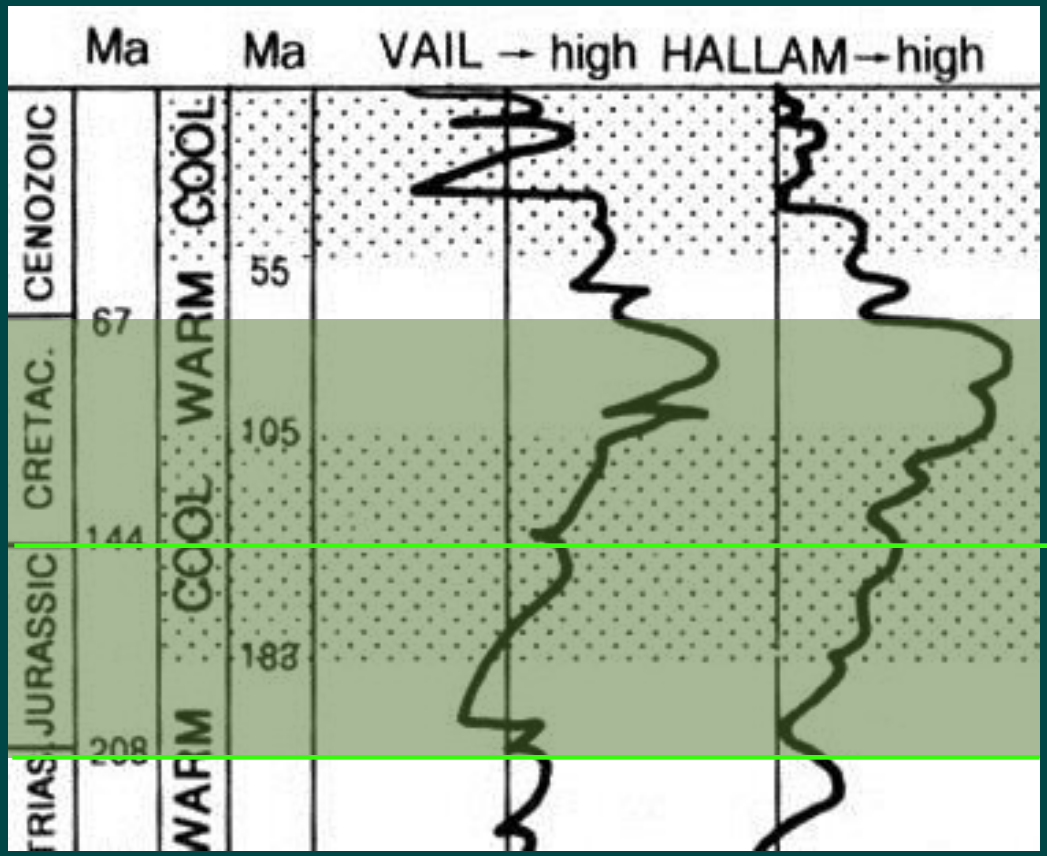
All these features are very advantageous to the larvae and taxa to survive and disperse (internal causes/ecological processes).

(Sha, 2001; Sha et al., 2002, 2014)

Currents, Eustatic sea level changes, Continental margins, Island stepping stones (external controls)

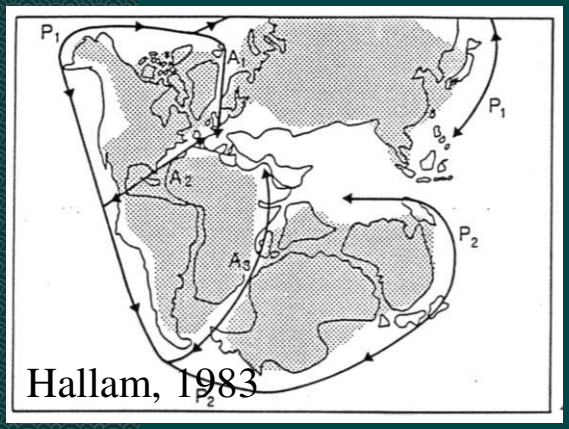


Predicated ocean currents in Mesozoic
(after Parrish, 1992)



(Hallam,1994)

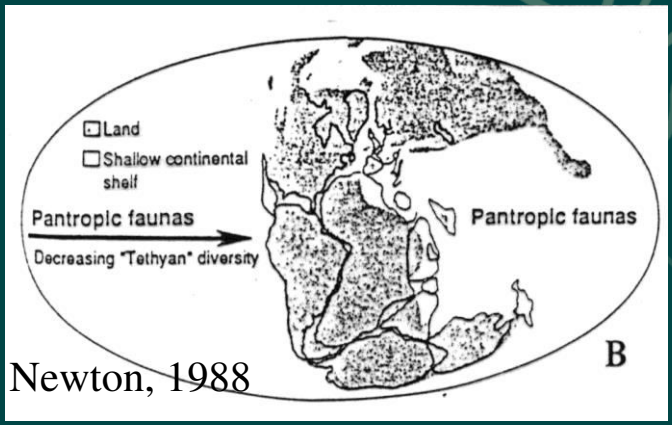
Sea level rising since earliest Jurassic



Hallam, 1983

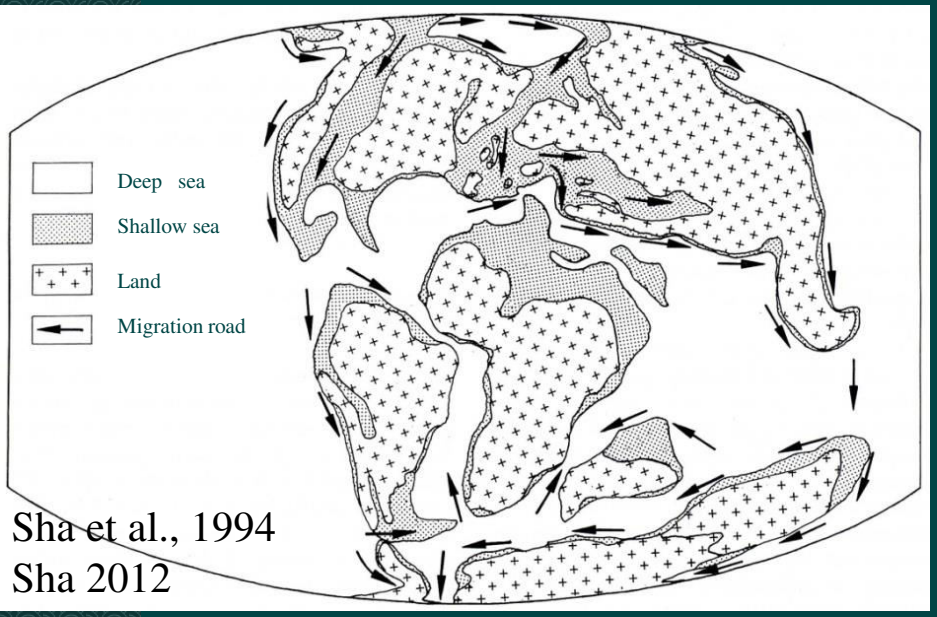


Ozawa et al., 1983



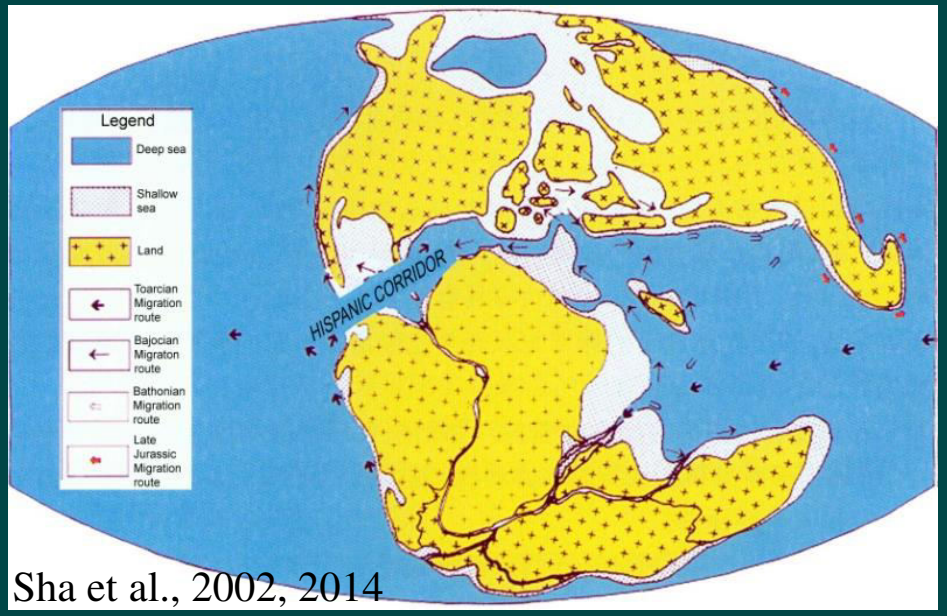
Newton, 1988

Bivalves dispersal/migation roads



Sha et al., 1994
Sha 2012

Bipolar bivalves



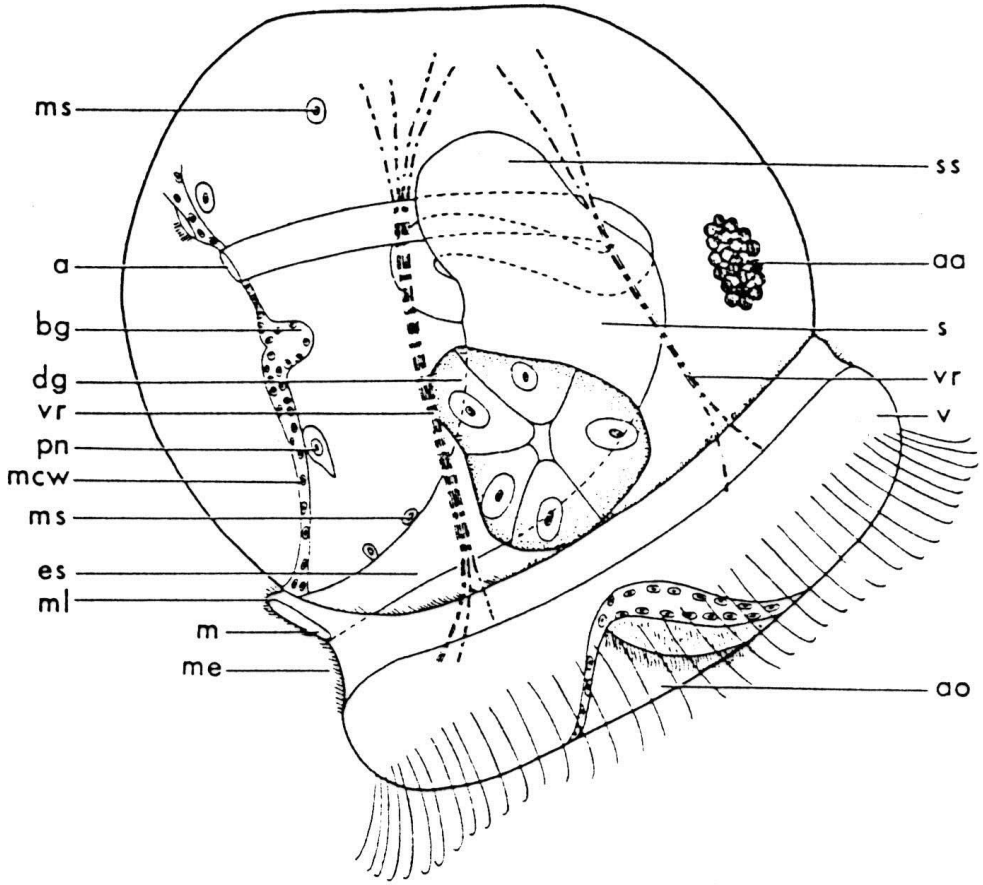
Sha et al., 2002, 2014

Pantropical bivalves

Through the plankton and pseudoplankton, with the oceanic currents, via island hopping, along continental margins, pantropic bivalves could cross the vast palaeo-Pacific from east to west in one or several generations. As a result, pantropic bivalves are always very similar, there are even some common species, which are good indicators of global stratigraphical correlation between Northern and Southern hemispheres.

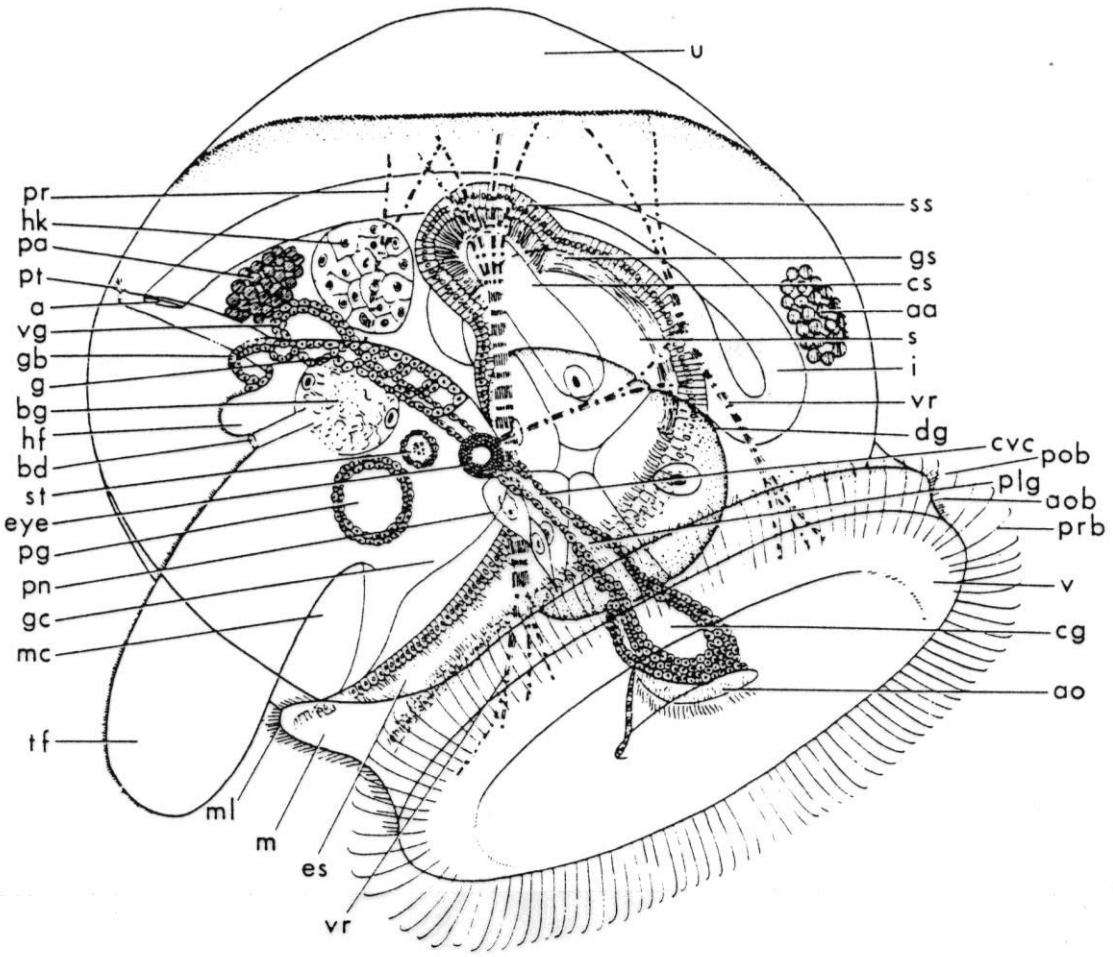
Thank You !

Veliger larva



Anatomy of a young, newly released, six-day-old veliger larva of *Ostrea edulis* (after PALMER 1989). a: anus, aa: anterior addctor, ao: apical organ, bg: primordial byssal gland, dg: digestive gland, es: esophagus, m: mouth, mcw: mantle cavity wall, me: mouth embayment, ml: mouth lobe, ms: free mesenchymal cell, pn: protonephridium, s: stomach, ss: style sac, v: velum, vr: velar retractor.

Pediveliger larva



Anatomy of a pediveliger larva of *Ostrea edulis* (after PALMER 1989). a: anus, aa: anterior adductor, ao: apical organ, acb: adoral ciliary band, bd: byssal gland duct, bg: byssal gland, cg: cerebral ganglion, cs: crystalline style, cvc: cerebropleural-visceral connective, dg: digestive gland, es: esophagus, eye: eye, g: gill primordium, gb: gill bridge, gc: gill cavity, gs: gastric shield, hf: heel of foot, hk: primordium of heart and kidney, i: intestine, m: mouth, mc: mantle cavity, ml: mouth lobe, pa: posterior adductor, pg: pedal ganglion, plg: pleural ganglion, pn: protonephridium, pob: postoral ciliary band, pr: pedal retractor, prb: preoral ciliary band, pt: postanal ciliary tuft, s: stomach, ss: style sac, st: statocyst, tf: toe of foot, u: umbo, v: velum, vg: visceral ganglion, vr: velar retractor.