Actin polymerization is not required for the fast block to polyspermy in the African clawed frog, *Xenopus laevis*

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Abstract

Fertilization of an egg by multiple sperm presents one of the earliest and most prevalent obstacles to successful reproduction. Eggs employ multiple mechanisms to prevent sperm entry into the nascent zygote. The fast block to polyspermy uses a depolarization to inhibit sperm entry. For some external fertilizers, fertilization and the fast block require actin polymerization. Here we explored whether the fast block to polyspermy in the external fertilizer, *Xenopus laevis*, requires actin polymerization. Inseminating in the presence of inhibitor cytochalasin B, here we demonstrate that actin polymerization is not required for the fast block to polyspermy in *X. laevis*. 
Figure 1: Representative whole-cell recordings made during fertilization in control conditions (A) or 10 µg/ml cytochalasin B (B). Grey dashed lines denote 0 mV. Tukey box plot distributions of the resting (n = 10) and fertilization (n = 4) potentials (C). (D) Average percentage (± s.e.m.) of embryos inseminated under control conditions (red) or with 10 µg/ml cytochalasin B (blue), that developed normally to the 4-cell (NF 3) stage, with incomplete cytokinesis, or with abnormal cleavage furrows (n
Methods suggest that actin polymerization is not required for the fast block to polyspermy. These data could have wider implications for how we think about polyspermy unlike sea urchins or the bivalve mollusk eggs. Not only does the egg remain fertilizable in the presence of cytochalasin B, it is capable of initiating the fast block to cytokinesis and yet be ineffective at inhibiting the polymerization required for fertilization-evoked depolarization. However, cortex. It is possible that this concentration of cytochalasin B may effectively inhibit the actin polymerization required for fertilization-evoked depolarization are different.

To determine whether 10 µg/ml cytochalasin B was acting on the X. laevis egg actin, we assessed cleavage furrow-development of the embryos. To form cleavage furrows, X. laevis eggs must undergo F-actin reorganization (Noguchi and Mabuchi, 2001), a process requiring actin polymerization. Furrow formation resulting in symmetric cleavage furrows with deep cleavages is associated with successful fast blocks to polyspermy and monospermic fertilization (Noguchi and Mabuchi, 2001). In 14 independent trials, sperm were added to groups of 10-50 eggs in 0 or 10 µg/ml cytochalasin B. 90 minutes after sperm addition, appearance of cleavage furrows was assessed for embryos in each condition. Whereas 86.6 ± 0.7% (n = 14) of eggs inseminated in 10 µg/ml cytochalasin B displayed incomplete cytokinesis (Figure 1E). When actin polymerization was completely inhibited, the zygotes displayed a white band of newly added plasma membrane without contraction of the egg cortex. It is possible that this concentration of cytochalasin B may effectively inhibit the actin polymerization required for cytokinesis and yet be ineffective at inhibiting the polymerization required for fertilization-evoked depolarization. However, cytochalasin B disruption of cytokinesis supports that the compound effectively inhibited actin polymerization in the X. laevis eggs. Not only does the egg remain fertilizable in the presence of cytochalasin B, it is capable of initiating the fast block to polyspermy unlike sea urchins or the bivalve mollusk Spisula. Because the drug acts on the microfilament system of the egg, these data could have wider implications for how we think about X. laevis fertilization. Together, the data presented here suggest that actin polymerization is not required for the fast block to polyspermy.
Request a detailed protocol

All animal protocols were conducted using accepted standards of humane animal care, approved by the Animal Care and Use Committee at the University of Pittsburgh. Adult *X. laevis* frogs were commercially purchased (Nasco) and housed at 18°C in 12/12 hr light and dark cycle. Ovulation was induced by injection of 1,000 IU of hCG into the dorsal lymph sac. Frogs were housed at 14°C for 14-16 hours after injection. Females typically began laying eggs 0-2 hours after their transfer to room temperature (22°C). Eggs were collected onto dry petri dishes and were used within 10 min.

Testes were collected from mature *X. laevis* males following euthanasia by a 30-min immersion in 3.6 g/L tricaine-S, pH 7.4. To create a sperm suspension, 1/10 of a testis was minced in MR/3. Eggs were inseminated by pipetting the sperm suspension onto the eggs bathed in MR/3. Dissected testes were stored at 4°C in L-15 medium and used within 5 days.

Modified Ringer’s (MR) solution used was composed of (in mM): 100 NaCl, 1.8 KCl, 2.0 CaCl$_2$, 1.0 MgCl$_2$, and 5.0 HEPES, pH 7.8. The MR was filtered using a sterile, 0.2-µm polystyrene filter. For fertilization-evoked depolarizations, eggs were inseminated in MR diluted to 20% MR (MR/5) for control conditions or in MR/5 with cytochalasin B added. After fertilization-evoked depolarizations were made for fertilization experiments, embryos were set aside to develop in MR diluted to 33% MR (MR/3). For developmental assays, embryos were incubated in MR/3 for control conditions or in MR/3 with cytochalasin B added.

Fertilization-evoked depolarizations were recorded as previously described (Wozniak et al. 2018). Briefly, recordings were made in the whole-cell using TEV-200A amplifiers (Dagan Co.) and digitized by Axon Digidata 1550A (Molecular Devices). The data were collected with pClamp Software (Molecular Devices) at a rate of 5 kHz. Pipettes made from borosilicate glass were 8–20 MΩ resistance and filled with 1 M KCl. Membrane potentials were quantified ∼10 s before (resting) and after (fertilization) the depolarization. Data were analyzed in Excel (Microsoft) and IGOR (Wavemetrics).

Approximately 10-50 eggs were inseminated in each experimental condition and then assessed for development based on the appearance of cleavage furrows (Figure 1E). Developmental phenotypes for each frog’s eggs were scored out of the total number of eggs fertilized and developed in each condition on each experimental day. All experiments were conducted at 22°C.

### Reagents

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**References**


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