View ScienceDirect over a secure connection: switch to HTTPS

ScienceDirect

Outline Download Export

Developmental Biology

Volume 252, Issue 1, 1 December 2002, Pages 100-118

Regular Article

Germ Line Development in the Grasshopper *Schistocerca gregaria*: *vasa* As a Marker

Chun-che Chang [1] … Michael Akam [3]

Show more

https://doi.org/10.1006/dbio.2002.0840

Get rights and content

Under an Elsevier user license

open archive

Abstract

Vasa is a widely conserved germline marker, both in vertebrates and invertebrates. We identify a *vasa* orthologue, *Sgvasa*, and use it to study germline development in the grasshopper *Schistocerca gregaria*, a species in which no germ plasm has been identified. In adults, *Sgvasa* is specifically expressed in the ovary and testis. It is expressed at high levels during early oogenesis, but no detectable *vasa* RNA and little Vasa protein are present in mature unlaid eggs. None appears to be localized to any defined region of the egg cortex, suggesting that germline specification may not depend on maternal germ plasm expressing *vasa*. Vasa protein is expressed in most cleavage energids as they reach the egg surface and persists at high levels in most cells aggregating to form the embryonic primordium. However, after gastrulation, Vasa protein persists only in extraembryonic membranes and in cells at the outer margin of the late heart-stage embryo. In the embryo, it then become restricted to cells at the dorsal margin of the forming abdomen. In older embryos, these Vasa-positive cells move toward the midline; Vasa protein accumulates asymmetrically in their cytoplasm, a pattern closely resembling that of germ cells in late embryonic gonads. Thus, we suggest that the Vasa-stained cells in the abdominal margin are germ cells, as proposed by Nelson (1934), and not cardioblasts, as has been proposed by others.

Keywords

arthropod; Orthoptera; germ cell; gonad; *vasa*; embryogenesis; ovary; testis; antibody

Recommended articles Citing articles (49)

References

REFERENCES

1 D.T. Anderson
The development of hemimetabolous insects
S.J. Counce, C.H. Waddington (Eds.), Developmental Systems: Insects, Academic Press, London (1972), pp. 96-165

2 D. Bentley, H. Keshishian, M. Shankland, A. Toroian-Raymond
Quantitative staging of embryonic development of the grasshopper, *Schistocerca nitens*
J. Embryol. Exp. Morphol., 54 (1979), pp. 47-74

3 A.K. Braat, T. Zandbergen, S. van de Water, H.J. Goos, D. Zivkovic

Feedback

Characterization of zebrafish primordial germ cells: Morphology and early distribution of *vasa* RNA
Dev. Dyn., 216 (1999), pp. 153-167

4 D. Carré, C. Djediat, C. Sardet
Formation of a large Vasa-positive germ granule and its inheritance by germ cells in the enigmatic Chaetognaths
Development, 129 (2002), pp. 661-670

5 P. Carrera, O. Johnstone, A. Nakamura, J. Casanova, H. Jäckle, P. Lasko
VASA mediates translation through interaction with a *Drosophila* yIF2 homolog
Mol. Cell, 5 (2000), pp. 181-187
Article PDF (436KB)

6 R. Dawes
Characterization of the locust *Dax* gene: Implication for a family of divergent Hox genes and their changing role in early development, University of CambridgeDepartment of Genetics (1996)

7 R. Dawes, I. Dawson, F. Falciani, G. Tear, M. Akam
***Dax*, a locust Hox gene related to *fushi-tarazu* but showing no pair-rule expression**
Development, 120 (1994), pp. 1561-1572

8 P. Dearden, M. Grbic, F. Falciani, M. Akam
Maternal expression and early zygotic regulation of the *Hox3/zen* gene in the grasshopper *Schistocerca gregaria*
Evol. Dev., 2 (2000), pp. 261-270

9 P.K. Dearden, M. Akam
Early embryo patterning in the grasshopper, *Schistocerca gregaria*: *wg*, *dpp* and *caudal* expression
Development, 128 (2001), pp. 3435-3444

10 K.E. Dixon
Evolutionary aspects of primordial germ cell formation
Ciba Found. Symp., 182 (1994), pp. 92-110

11 D.R. Dorer, A.C. Christensen, D.H. Johnson
A novel RNA helicase gene tightly linked to the Triplo-lethal locus of *Drosophila*
Nucleic Acids Res., 18 (1990), pp. 5489-5494

12 R. Dorn, H. Morawietz, G. Reuter, H. Saumweber
Identification of an essential *Drosophila* gene that is homologous to the translation initiation factor eIF-4A of yeast and mouse
Mol. Gen. Genet., 237 (1993), pp. 233-240

13 E.M. Eddy
Germ plasm and the differentiation of the germ cell line
Int. Rev. Cytol., 43 (1975), pp. 229-280

14 S.E. Frenk Mora
Embryology in its relation to genetics and evolution, University of CambridgeDepartment of Genetics (1993)

15 M. Fujimura, K. Takamura
Characterization of an ascidian DEAD-box gene, *Ci-DEAD1*: Specific expression in the germ cells and its mRNA localization in the posterior-most blastomeres in early embryos
Dev. Genes Evol., 210 (2000), pp. 64-72

16 Y. Fujiwara, T. Komiya, H. Kawabata, M. Sato, H. Fujimoto, M. Furusawa, T. Noce
Isolation of a DEAD-family protein gene that encodes a murine homologue of *Drosophila vasa* and its specific expression in germ cell lineage
Proc. Natl. Acad. Sci. USA, 91 (1994), pp. 12258-12262

17 A. Ghabrial, T. Schupbach
Activation of a meiotic checkpoint regulates translation of Gurken during *Drosophila* oogenesis
Nat. Cell Biol., 6 (1999), pp. 354-357

18 E.R. Gavis, L. Lunsford, S.E. Bergsten, R. Lehmann
A conserved 90 nucleotide element mediates translational repression of *nanos* RNA
Development, 122 (1996), pp. 2791-2800

Development, 122 (1996), pp. 2791-2800

19 M.E. Gruidl, P.A. Smith, K.A. Kuznicki, J.S. McCrone, J. Kirchner, D.L. Roussell, S. Strome, K.L. Bennett
Multiple potential germ-line helicases are components of the germ-line-specific P granules of *Caenorhabditis elegans*
Proc. Natl. Acad. Sci. USA, 93 (1996), pp. 13837-13842

20 R. Gururajan, H. Perry-O'Keefe, D.A. Melton, D.L. Weeks
The *Xenopus* localized messenger RNA An3 may encode an ATP-dependent RNA helicase
Nature, 349 (1991), pp. 717-719

21 E. Harlow, D. Lane
Antibodies: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor (1988)

22 B. Hay, L.Y. Jan, Y.N. Jan
A protein component of *Drosophila* polar granules is encoded by *vasa* and has extensive sequence similarity to ATP-dependent helicases
Cell, 55 (1988), pp. 577-587
Article PDF (9MB)

23 B. Hay, L.Y. Jan, Y.N. Jan
Localization of *vasa*, a component of *Drosophila* polar granules, in maternal-effect mutants that alter embryonic anteroposterior polarity
Development, 109 (1990), pp. 425-433

24 K. Ho, O.M. Dunin-Borkowski, M. Akam
Cellularization in locust embryos occurs before blastoderm formation
Development, 124 (1997), pp. 2761-2768

25 K. Ikenishi
Germ plasm in *Caenorhabditis elegans*, *Drosophila* and *Xenopus*
Dev. Growth Differ., 40 (1998), pp. 1-10

26 H. Knaut, F. Pelegri, K. Bohmann, H. Schwarz, C. Nusslein-Volhard
Zebrafish *vasa* RNA but not its protein is a component of the germ plasm and segregates asymmetrically before germline specification
J. Cell Biol., 149 (2000), pp. 875-888

27 T. Kobayashi, H. Kajiura-Kobayashi, Y. Nagahama
Differential expression of *vasa* homologue gene in the germ cells during oogenesis and spermatogenesis in a teleost fish, *Tilapia, Oreochromis niloticus*
Mech. Dev., 99 (2000), pp. 139-142
Article PDF (950KB)

28 T. Komiya, K. Itoh, K. Ikenishi, M. Furusawa
Isolation and characterization of a novel gene of the DEAD box protein family which is specifically expressed in germ cells of *Xenopus laevis*
Dev. Biol., 162 (1994), pp. 354-363
Article PDF (862KB)

29 T. Komiya, Y. Tanigawa
Cloning of a gene of the DEAD box protein family which is specifically expressed in germ cells in rats
Biochem. Biophys. Res. Commun., 207 (1995), pp. 405-410
Article PDF (372KB)

30 P. Lasko
RNA sorting in *Drosophila* oocytes and embryos
FASEB J., 13 (1999), pp. 421-433

31 P.F. Lasko, M. Ashburner
The product of the *Drosophila* gene *vasa* is very similar to eukaryotic initiation factor-4A
Nature, 335 (1988), pp. 611-617

32 P.F. Lasko, M. Ashburner
Posterior localization of Vasa protein correlates with, but is not sufficient for, pole cell development

Genes Dev., 4 (1990), pp. 905-921

33 K.A. Lawson, N.R. Dunn, B.A. Roelen, L.M. Zeinstra, A.M. Davis, C.V. Wright, J.P. Korving, B.L. Hogan
Bmp4 is required for the generation of primordial germ cells in the mouse embryo
Genes Dev., 13 (1999), pp. 424-436

34 L. Liang, W. Diehl-Jones, P. Lasko
Localization of Vasa protein to the *Drosophila* pole plasm is independent of its RNA-binding and helicase activities
Development, 120 (1994), pp. 1201-1211

35 A.P. Mahowald, R.E. Boswell
Germ plasm and germ cell development in invertebrates
A. Mclaren, C.C. Wylie (Eds.), Current Problems in Germ Cell Differentiation, Cambridge Univ. Press, New York (1983), pp. 3-17

36 F.H. Markussen, A.M. Michon, W. Breitwieser, A. Ephrussi
Translational control of *oskar* generates short OSK, the isoform that induces pole plasma assembly
Development, 121 (1995), pp. 3723-3732

37 A. McLaren
Signaling for germ cells
Genes Dev., 13 (1999), pp. 373-376

38 K. Mochizuki, C. Nishimiya-Fujisawa, T. Fujisawa
Universal occurrence of the *vasa*-related genes among metazoans and their germline expression in *Hydra*
Dev. Genes Evol., 211 (2001), pp. 299-308

39 H. Nakao
Isolation and characterization of a *Bombyx vasa*-like gene
Dev. Genes Evol., 209 (1999), pp. 312-316

40 O.E. Nelsen
The development of the ovary in the grasshopper, *Melanopus differentialis* (Acridiidae; Orthoptera)
J. Morphol., 55 (1934), pp. 515-543

41 O.E. Nelsen
The segregation of the germ cells in the grasshopper, *Melanopus differentialis* (Acridiidae; Orthoptera)
J. Morphol., 55 (1934), pp. 545-565

42 P.D. Nieukoop, L.A. Sutasurya
Primordial Germ Cells of the Invertebrates, Cambridge Univ. Press, Cambridge (1981)

43 L.C. Olsen, R. Aasland, A. Fjose
A *vasa*-like gene in zebrafish identifies putative primordial germ cells
Mech. Dev., 66 (1997), pp. 95-105
Article PDF (1MB)

44 E. Raz
The function and regulation of *vasa*-like genes in germ-cell development
Genome Biol., 1 (2000), pp. 1017.1-1017.6

45 C. Rongo, H.T. Broihier, L. Moore, M. Van-Doren, A. Forbes, R. Lehmann
Germ plasm assembly and germ cell migration in *Drosophila*
Cold Spring Harbor Symp. Quant. Biol., 62 (1997), pp. 1-11

46 C. Rongo, E.R. Gavis, R. Lehmann
Localization of *oskar* RNA regulates *oskar* translation and requires Oskar protein
Development, 121 (1995), pp. 2737-2746

47 M.L. Roonwal
Studies on the embryology of the African migratory locust *Locusta migratoria migratoroide*s. II. Organogeny
Philos. Trans. R. Soc. Lond. B Biol. Sci., 227 (1937), pp. 175-224

48 D.L. Roussell, K.L. Bennett
***glh-1*, a germ-line putative RNA helicase from *Caenorhabditis*, has four zinc fingers**

***gli-1*, a germ-line putative RNA helicase from *Caenorhabditis*, has four zinc fingers**
Proc. Natl. Acad. Sci. USA, 90 (1993), pp. 9300-9304

49 E.E. Saffman, P. Lasko
Germline development in vertebrates and invertebrates
Cell Mol. Life Sci., 55 (1999), pp. 1141-1163

50 N. Shibata, Y. Umesono, H. Orii, T. Sakurai, K. Watanabe, K. Agata
Expression of *vasa* (*vas*)-related genes in germline cells and totipotent somatic stem cells of planarians
Dev. Biol., 206 (1999), pp. 73-87
Article PDF (905KB)

51 A. Shinomiya, M. Tanaka, T. Kobayashi, Y. Nagahama, S. Hamaguchi
The *vasa*-like gene, *olvas*, identifies the migration path of primordial germ cells during embryonic body formation stage in the medaka, *Oryzias latipes*
Dev. Growth. Differ., 42 (2000), pp. 317-326

52 S.S. Tanaka, Y. Toyooka, R. Akasu, Y. Katoh-Fukui, Y. Nakahara, R. Suzuki, M. Yokoyama, T. Noce
The mouse homologue of *Drosophila vasa* is required for the development of male germ cells
Genes Dev., 14 (2000), pp. 841-853

53 R. Tinker, D. Silver, D.J. Montell
Requirement for the *vasa* RNA helicase in *gurken* mRNA localization
Dev. Biol., 199 (1998), pp. 1-10
Article PDF (9MB)

54 Y. Toyooka, N. Tsunekawa, Y. Takahashi, Y. Matsui, M. Satoh, T. Noce
Expression and intracellular localization of mouse Vasa-homologue protein during germ cell development
Mech. Dev., 93 (2000), pp. 139-149
Article PDF (1MB)

55 N. Tsunekawa, M. Naito, Y. Sakai, T. Nishida, T. Noce
Isolation of chicken *vasa* homologue gene and tracing the origin of primordial germ cells
Development, 127 (2000), pp. 2741-2750

56 G. Wei, A.P. Mahowald
The germline: Familiar and newly uncovered properties
Annu. Rev. Genet., 28 (1994), pp. 309-324

57 W.M. Wheeler
A contribution to insect embryology
J. Morphol., 8 (1893), pp. 1-160

58 U. Wolke, G. Weidinger, M. Koprunner, E. Raz
Multiple levels of posttranscriptional control lead to germline-specific gene expression in the zebrafish
Curr. Biol., 12 (2002), pp. 289-294
Article PDF (459KB)

59 C. Wylie
Germ cells
Cell, 96 (1999), pp. 165-174
Article PDF (77KB)

60 C. Yoon, K. Kawakami, N. Hopkins
Zebrafish *vasa* homologue RNA is localized to the cleavage planes of 2- and 4-cell-stage embryos and is expressed in the primordial germ cells
Development, 124 (1997), pp. 3157-3165

61 G. Yoshizaki, S. Sakatani, H. Tominaga, T. Takeuchi
Cloning and characterization of a *vasa*-like gene in rainbow trout and its expression in the germ cell lineage
Mol. Reprod. Dev., 55 (2000), pp. 364-371

62 D. Zissler
From egg to pole cells: Ultrastructural aspects of early cleavage and germ cell determination in insects

Microsc. Res. Tech., 22 (1992), pp. 49-74

1 Present address: Department of Genetics, University of Leicester, University Road, Leicester LE1 7RH, UK.

2 Present address: Biochemistry Department, University of Otago, 710 Cumberland Road, Box 56, Dunedin, New Zealand.

3 To whom correspondence should be addressed. Fax: +44 1223 336679. E-mail: m.akam@zoo.cam.ac.uk.

Copyright © 2002 Elsevier Science (USA). All rights reserved.

ELSEVIER

About ScienceDirect Remote access Shopping cart Contact and support Terms and conditions Privacy policy

Cookies are used by this site. For more information, visit the cookies page.
Copyright © 2017 Elsevier B.V. or its licensors or contributors. ScienceDirect ® is a registered trademark of Elsevier B.V.

RELX Group™